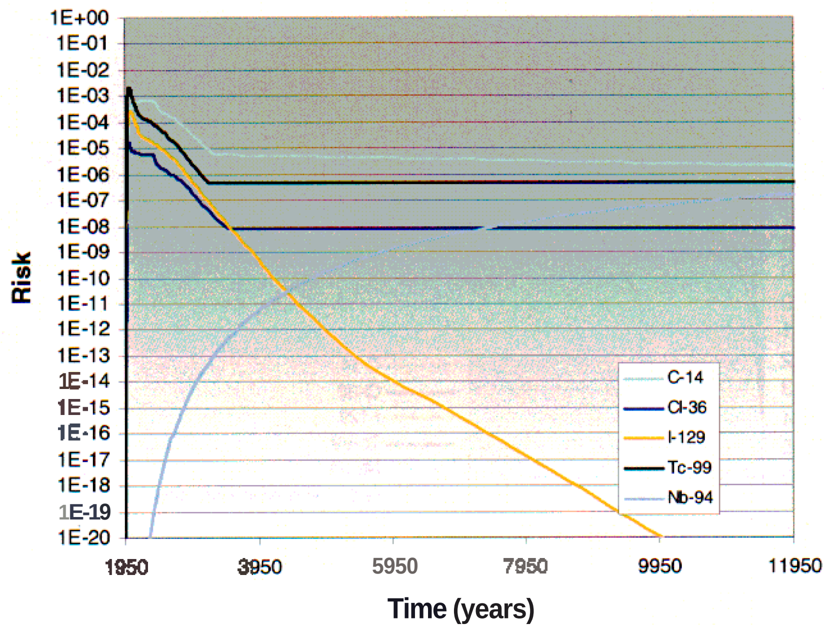

Figure 6-77. Simulated maximum groundwater ingestion risks for Group 7 contaminants over 10,000 years anywhere in the aquifer.

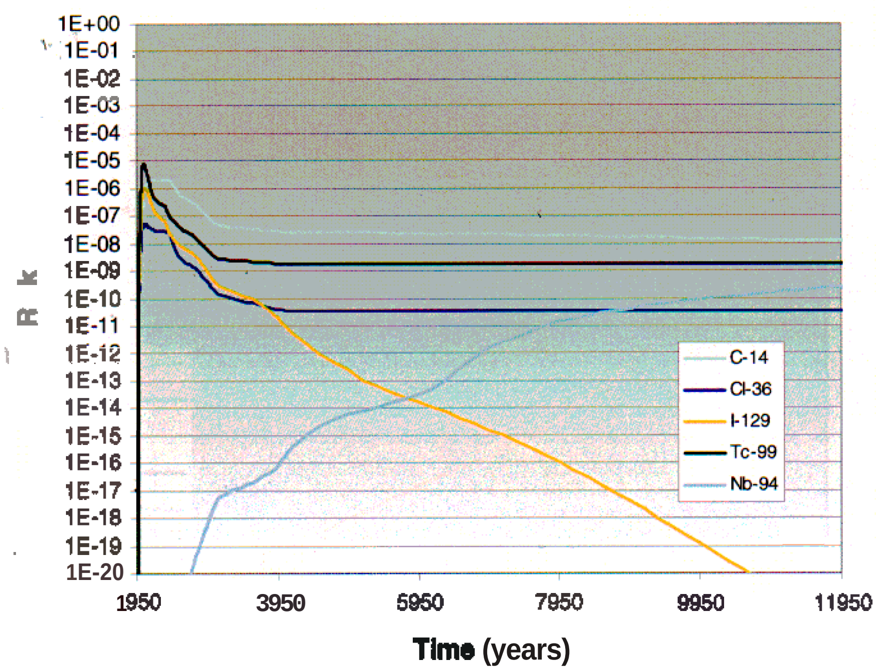

Figure 6-78. Simulated maximum groundwater ingestion risks for Group 7 contaminants over 10,000 years at the southern Idaho National Engineering and Environmental Laboratory boundary.

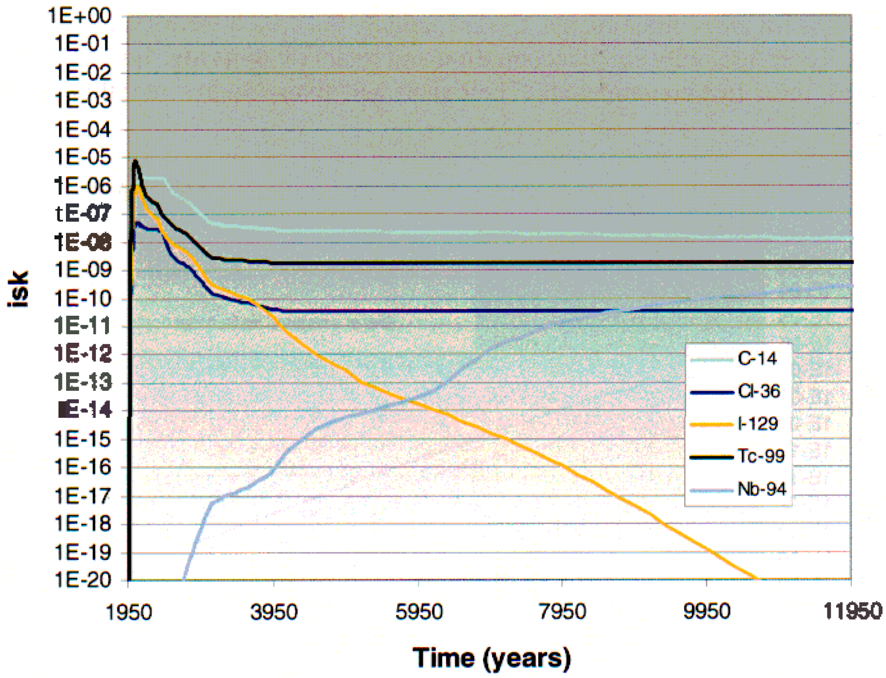

Figure 6-79. Simulated maximum groundwater ingestion risks for Group 7 contaminants over 10,000 years at the southern Idaho National Engineering and Environmental Laboratory boundary.

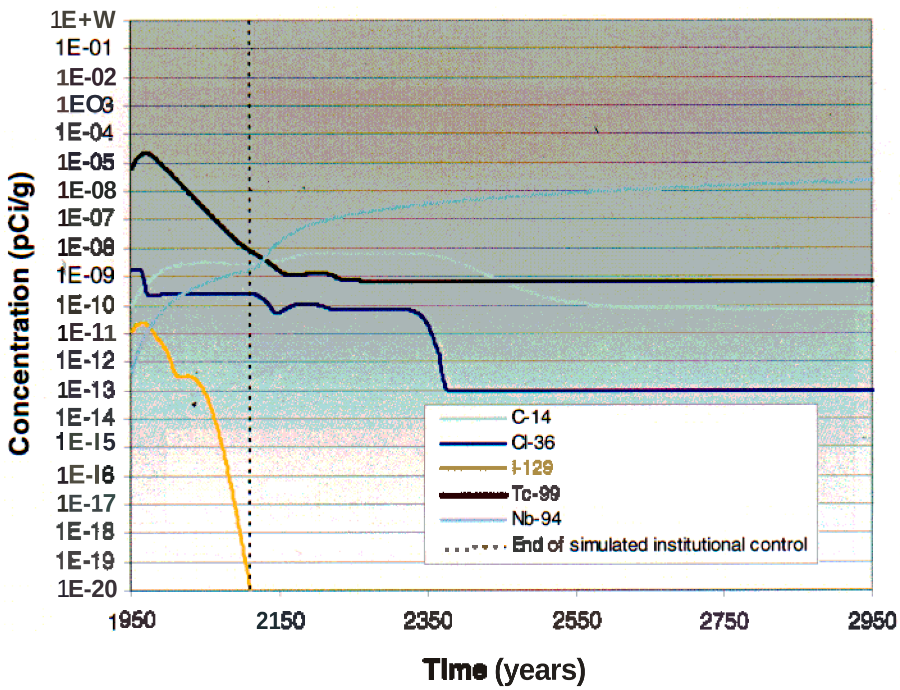

Figure 6-80. Simulated soil concentrations for Group 7 contaminants.

6.4.3.8 *Surface Exposure Pathway Contaminants.* This subsection provides simulated risk and concentration plots for two contaminants, Cs-137, and Sr-90, which were evaluated only for surface exposure pathways. Therefore, only soil concentration and total risk plots are shown because groundwater was not simulated for these two contaminants. Their short half-lives and low mobility preclude them from impacting the aquifer.

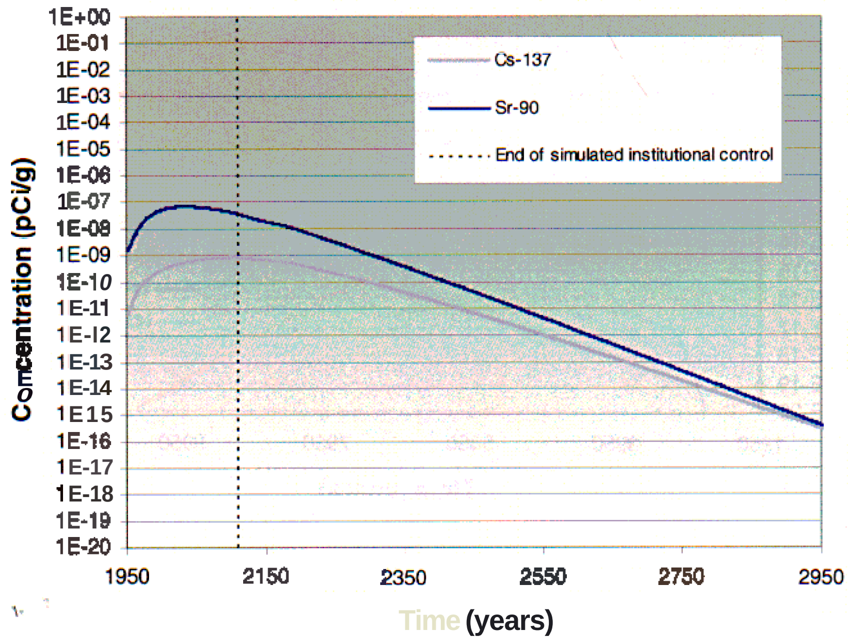

Figure 6-81. Simulated soil concentrations for Group 8 contaminants.

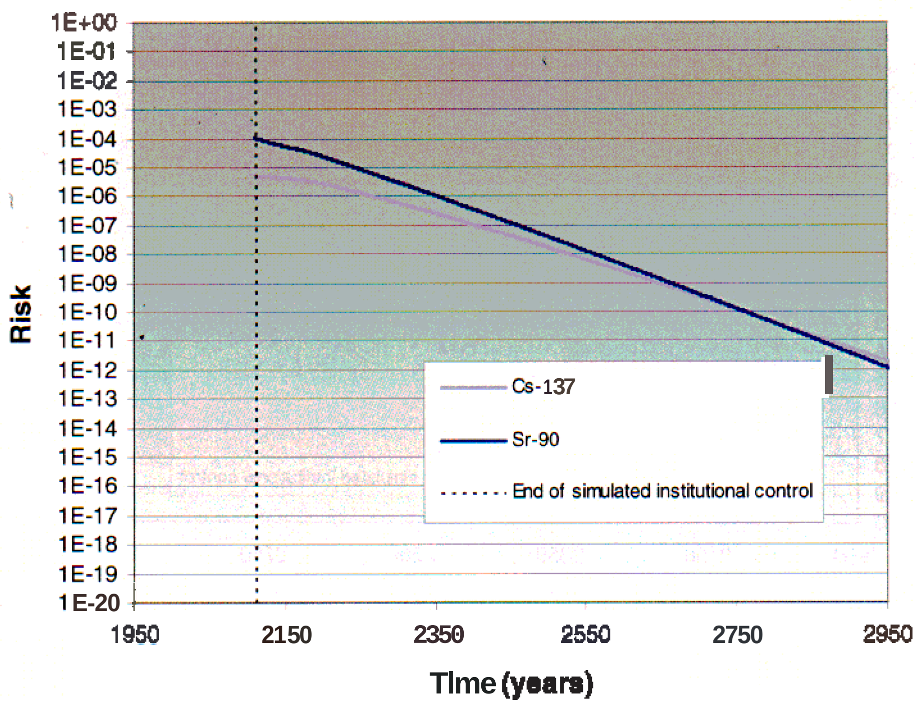

Figure 6-82. Total carcinogenic risk for Group 8 contaminants for hypothetical future residential exposure pathways.

6.5 Uncertainties in the Human Health Baseline Risk Assessment

Results presented in this ABRA are dependent on methodologies described in Sections 5 and **6.** Developed over a period of several years by INEEL risk assessment and risk management professionals, these methods provide the most realistic, and yet conservative, estimates of human health risks that can be produced for WAG 7 with the data currently available. Nonetheless, if different risk assessment methods or different assumptions had been used, the ABRA likely would have produced different risk assessment results. This section presents the uncertainties associated with the ABRA results. The uncertainties are classified into three broad categories: (a) scenario uncertainty, (b) model uncertainty, and (c) parameter uncertainty. Each category is discussed below.

6.5.1 Scenario Uncertainty

Scenario uncertainty incorporates the uncertainty associated with future land use at the INEEL and the choice of exposure scenarios assessed. The scenario choices were described earlier as critical assumptions for the overall risk assessment. Furthermore, many of the other assumptions are based on the scenario choices, making the scenario uncertainty difficult to quantify. Scenarios were chosen that are consistent with INEEL land-use documents (DOE-ID 1995, 1996), provide direct comparison with similar scenarios in other INEEL risk assessments, and generate reasonable upper-bound estimates of the potential risk to human health.

An occupational exposure scenario was chosen for the next 100 years because DOE Order 435.1-1 requires 100 years of institutional control after closure of a LLW disposal facility. It is not clear whether the exposure assumptions of 25 years of exposure for 8 hours a day are representative of a closed LLW disposal facility, but this should provide a reasonable upper-bound estimate of the potential exposure. The choice of exposure parameter values is discussed in more detail in Section 6.5.3.

After the assumed 100-year institutional control period following closure of the current LLW disposal, land use at the RWMC is uncertain. Parts of the INEEL could be returned to public use. Though future residential development at the INEEL may seem improbable, assuming residential use generates reasonable upper-bound risk estimates. Other scenarios such as recreational use would produce lower potential risk estimates. However, direct intrusion into the waste would be unlikely because of deed restrictions and other closure procedures at the RWMC. Therefore, the residential scenario addressed living adjacent to the SDA but did not assess intruding directly into the waste.

6.5.2 Model Uncertainty

Model uncertainty describes the degree to which a model represents the physical system that the model simulates. All models are simplifications of a real physical system. The issue becomes whether the model contains enough detail to adequately represent the physical system and whether the appropriate choice of inputs can be made to match that physical system. As with scenario uncertainty, it is nearly impossible to quantify model uncertainty. At best, the uncertainty can be minimized by comparing results to known solutions and by calibrating the model to measured data.

Models used for this ABRA were compared to measured data. Some components of the model had fewer available comparison data than others. Little source term or biotic data exist with which to calibrate the models. Section **5.4** presents results of the comparisons for the groundwater model.

6.5.3 Parameter Uncertainty

Many of the parameters used as inputs to the models have associated uncertainties. In the **ABRA,** conservative assumptions for the parameters were developed in an effort to provide reasonable upper-bound risk estimates. However, as conservative assumptions were made at each step in the process, the resulting degree of cumulative conservatism was difficult to determine. Evaluations of the uncertainty can range from a qualitative assessment to sophisticated methods that propagate the uncertainty through the models used to derive original risk estimates. Even though many simulations were performed to determine the probable range of uncertainty for specific parameters, overall uncertainty was not quantified. Uncertainty is addressed in a qualitative manner in Section **6.5.3.1.**

6.5.3.1 Qualitative Uncertainty Analysis. Overall uncertainty is discussed qualitatively in this section, and then specific contaminants that cannot be analyzed quantitatively with currently available information are discussed. Contaminants were identified in the contaminant screening documented in the Work Plan (Becker et al. **1996).**

The risk estimates found in this report are products of a four-step process:

1. Data collection and evaluation
2. Exposure assessment
3. Toxicity assessment
4. Risk characterization.

The uncertainties in each of these steps are discussed in the following sections.

6.5.3.1.1 Data Collection and ***Evaluation—***The nine-step process recommended by the EPA **(1989)** to assess data usability for risk assessment is listed as follows:

1. Gather all available data and sort by medium
2. Evaluate the analytical methods used
3. Evaluate data in accordance with sample quantitation limits
4. Evaluate data in accordance with data flags and qualifiers
5. Evaluate data in accordance with contamination found in laboratory blanks
6. Evaluate tentatively identified compounds
7. Compare data to background concentrations
8. Develop the data set for risk assessment
9. If appropriate, screen the list to limit the number of contaminants to be evaluated.

Samples are handled by analytical laboratories that are subcontracted to the INEEL and certified by the Contract Laboratory Program. Numerous quality assurance and quality control precautions are implemented during sampling, handling, analysis, and data management to ensure that sampling data meet data usability criteria (see Section **4.5.1)** and are assigned the appropriate data quality flags. Even given this level of rigor in sampling and analysis methods, occasionally data pass all the tests but may still be suspect. Because of the importance of the decisions these data may support, further data review may be justified.

One such case involved detection of plutonium in the sedimentary interbeds. Originally, detections in the interbeds were assumed to be the result of down-hole contamination during the drilling of wells. However, data were subjected to independent review and determined to be valid detections and not the result of down-hole contamination. Use of these data in comparison to model predictions is discussed in Section **5.3.2.6.**

In addition to contaminant concentrations, other types of data were used in the models but were not subjected to the standard quality control procedures associated with determining media concentrations using the Contract Laboratory Program. All available data were evaluated to determine whether they were of sufficient quality to be used as input for modeling. Model inputs are discussed in Section **5.** Site-specific data of sufficient quality were used when available. If site-specific data were not available, the literature was reviewed to determine values appropriate for conditions at the SDA. Examples of other types of data used include the following:

- Lithologic logs from well-drilling operations. Logs were used to determine the relative thickness of the basalt flows and interbeds in the subsurface model.

- Soil-to-water partition coefficients. Priority was given to site-specific data developed using native soil in column tests. When this type of data was unavailable, national databases were searched for appropriate values. (Note that flow through the basalt is assumed to be in fractures and partitioning is minimal, and assumed to be zero in the model.)

- Container failure data taken from waste retrieval operations.

- Beryllium reflector block corrosion rates, which were estimated analytically based on sample data corrected for site-specific conditions.

- National Bureau of Standards data, which were used to estimate stainless steel corrosion rates.

- The contaminant inventory, which was the result of reviewing the disposal records and directly contacting personnel at the waste generators to validate the amounts.

Comparing the modeling results to measured concentrations is the ultimate test of a model and all its associated input. Comparisons of simulated concentrations to the measured aquifer concentrations are discussed in Section **5.3.** In most cases, the model provided a reasonable match to measured data. In a few cases, the model predictions were grossly inconsistent with measured concentrations. Therefore, the input data were evaluated to analyze the lack of agreement. In some cases, independent reviews of the original data determined the source of the error, and the input was corrected. In other cases, the need for further investigation was warranted. A parametric uncertainty analysis is documented in Section **6.5.3.2** to address input where additional data could not be gathered in a timely manner to support this analysis.

6.5.3.1.2 Exposure Assessment — Uncertainties associated with the exposure assessment are produced by inadequate source term inventories; characterizing transport, dispersion, and transformation of COPCs in the environment; establishing exposure settings; and deriving estimates of chronic intake. The initial characterization that defines the exposure setting for a site requires many professional judgments and assumptions. Definition of the physical setting, population characteristics, and selection of the chemicals included in the **ABRA** are examples of areas for which a quantitative estimate of uncertainty cannot be achieved because of the inherent reliance on professional judgment.

Contaminant inventories used in the analysis introduce uncertainty into the model results. As discussed in Section 3.3, several corrections, revisions, and updates were applied to source term inventories originally developed in the HDT and RPDT (LMITCO 1995a, 1995b). Some inventories, specifically those attributed in Table 5-3 to INEEL reactor operations, are still in review. Corrections to CIDRA were implemented for the ABRA, but are subject to change.

Release parameters used in the source term model also can introduce large uncertainty in the exposure assessment. For example, the solubility of uranium can vary by more than 10 orders of magnitude. Because the chemical form of the uranium disposed of is unknown, conservative release rates were used. A parametric analysis of the expected values is presented later in this section.

Uncertainties from the subsurface fate and transport modeling also contribute to uncertainties in the exposure assessment. The primary uncertainties are the contaminant inventories and release rates. Also important are the amount and timing of infiltration through the buried waste, the possibility of preferential pathways through the vadose zone, the influence of spreading area water in the vadose zone, and low permeability region in the aquifer that affects dilution of contaminants emanating from the vadose zone. Sensitivity analyses related to each of these uncertainties are included in this section.

Exposure and intake parameters used in the ABRA were EPA default values, developed to provide a reasonable upper-bound estimate of exposure. The combination of exposure parameters protects the population at greater than the 90th percentile for each exposure pathway. In addition, the exposure assumptions included the assumption that a worker or resident is actually at the site to receive an exposure. As noted in Section 6.5.1, the assumption is conservative.

In addition, a "double accounting" was made of the constituent mass. All the mass released by the source term model was available for transport by the subsurface model. Part of the mass released by the source term model also was available for transport by the biotic model. The ABRA modeling minimized the double accounting by simulating the subsurface transport to the aquifer by leaching mass from the biotic model. The net effect of the double accounting on the total risk should have been negligible because of accounting for the leaching in the biotic model.

6.5.3.1.3 Toxicity Assessment—Several important measures of toxicity are needed to conduct an assessment of risk to human health. For example, RfDs are applied to oral and inhalation exposure to evaluate noncarcinogenic and developmental effects, and SFs are applied to oral and inhalation exposures to carcinogens. The RfDs are derived from no observable effect level or lowest observable adverse effect level and applying uncertainty factors and modifying factors. Uncertainty factors are used to account for variation in sensitivity of human subpopulations and the uncertainty inherent in extrapolation of results of animal studies to humans. Modifying factors account for additional uncertainties in the studies used to derive the no observable effect level or lowest observable adverse effect level. Uncertainty associated with SFs is accounted for by an assigned weight-of-evidence rating that reflects the likelihood that a toxicant is a human carcinogen. Weight-of-evidence classifications are tabulated and included in Table 6-3, and a discussion of the factors used to derive RfDs is presented in Section 6.3.

6.5.3.1.4 Risk Characterization — The last step in the ABRA is risk characterization. As discussed in Section 6.4, risk characterization is the process of integrating results of the exposure and toxicity assessments. Uncertainties defined throughout the analysis process are combined and presented as part of the risk characterization to provide an understanding of the overall uncertainty inherent in the risk estimates. This qualitative assessment of uncertainty is presented in Table 6-8. In general, risk results are biased high to be protective of human health. A sensitivity study is presented below to illustrate some of the specific parameters that generate uncertainty in the risk estimates.

6.5.3.2 Quantitative Sensitivity Analysis. Sensitivity was analyzed for several parameters to assess the effect of the uncertainty on the overall risk results. Table 6-9 presents a summary of the sensitivity analysis performed. The sensitivity analysis focused on the groundwater ingestion pathway.

6.5.3.2.7 ***Inventory Uncertainty***—Upper-bound inventories were used to address the uncertainty based on the inventory. Section 3 provides a summary of the work performed to correct the inventory and provide upper bounds used for this analysis. Figure 6-83 shows the total estimated risk for groundwater ingestion from the radionuclides. The peak total risk increased from 5E-03 to 3E-02. However, that peak occurred during the simulated 100-year institutional control period. The peak after institutional control is 2E-02, and it occurs at the year 3110. The inventory uncertainty is a factor of 4 on the total risk. Risks shown before the year 2110 are for comparison only because exposure to contaminated groundwater during the simulated 100-year institutional control would be prevented in that time period.

6.5.3.2.2 Plutonium Mobility—Two different sensitivity cases were implemented to mimic postulated enhanced mobility of plutonium in the environment. The first case applied various soil-to-water partition coefficients (K_d) and the second simulated small fractional releases of highly mobile plutonium. For the change in partition coefficient, the base case, computed using the site-specific plutonium partition coefficient of 5,100 mL/g, was compared to sensitivity cases with partition coefficients of 22,320, and 1,700 mL/g for simulation Group 2 (Pu-239) and Group 4 (Pu-238). The value of 22 mL/g is for crushed basalt and is the screening value from the Track 2 Guidance (DOE 1994). The values 320 mL/g and 1,700 mL/g come from ***Understanding Variation in Partition Coefficient, K_d Values*** (EPA 1999). The values were roughly an order of magnitude spaced between the baseline number and the screening number. In addition, the value of 1,700 mL/g was used for the barrier material in the ICDF PA. Results are illustrated in Figure 6-84 for Pu-239. The estimated aquifer concentrations for all K_ds used are lower than 1E-02 pCi/L, which is less than detectable with routine analytical methods. However, for K_d = 22 mL/g, vadose zone media (i.e., core data and routine soil moisture monitoring) concentrations would be detectable with widespread detections about two orders of magnitude higher than reported observations. At this point, the lowest plutonium K_d can be eliminated based on measurements in the vadose zone. Data from continued monitoring can improve the description of plutonium transport mechanisms needed to quantify mobility. Fractions of plutonium mass may be exhibiting facilitated transported, as assessed in the graphs below. The risk for Pu-238 is shown in Figure 6-85. With its shorter half-life, the groundwater risks from Pu-238 are lower even with the greater mobility. Concentrations and risks shown before the year 2110 are for comparison only. Exposure to contaminated groundwater in the INEEL would be prevented during the simulated 100-year institutional control period.

To address the possibility of a tiny mobile fraction of plutonium, the release of plutonium was set to a fraction and the mobility (K_d) was set to 0.1. This allowed for some sorption to interbed soil and comparison to measured results. Three fractions were simulated to cover a complete range of possibilities. The three fractions are 1E-02, 1E-04, and 1E-06. Figure 6-86 shows the risk for Pu-239 for the three fractions compared to the base case. Figure 6-87 shows the analogous results for Pu-238. Aquifer concentrations predicted for any of these cases are far above anything that has been measured, and clearly overestimate the actual release that might have occurred by this mechanism. Therefore, the fractional release for any small mobile fraction must be less than 1E-06 per year or additional detections in the aquifer would be seen. Mobile fractions of 1E-04 and 1E-02 overpredict measured soil moisture concentrations in the vadose zone. The 1E-06 fraction does not contradict measured values. Concentrations and risks shown before the year 2110 are for comparison only. Exposure to contaminated groundwater in the INEEL would be prevented during the simulated 100-year institutional control period. As stated above, continued monitoring can be used to assess mobility and the mechanisms of transport for plutonium.

Table 6-8. Human health uncertainty factors.

Uncertainty Factor	Effect of Uncertainty	Comment
Source term assumptions	May overestimate risk	The release assumptions used site-specific data where available but a lack of geochemistry information within the waste precludes a full understanding of the release rate. In general it is believed that conservative assumptions were used when the data were uncertain.
Source term inventories	May overestimate or underestimate risk	The model used best-estimate inventories estimates that were still under review when the simulations were performed. Depending on the results of the review, the inventories of some contaminants may increase or decrease.
Natural infiltration rate	May overestimate or underestimate risk	Value used is based on site-specific measurements outside the waste. Measurements within the waste would help reduce this uncertainty.
Moisture content	May overestimate or underestimate risk	Soil moisture contents vary seasonally in the upper vadose zone and may be subject to measurement error.
Water table fluctuations	May overestimate	Flow reversals would cause additional spreading (dilution) and reduce concentrations.
Spreading area influences	May overestimate or underestimate risk	Depending on the magnitude of the influence, the dilution provided by the addition of spreading area water would increase or decrease the risk relative to the predicted values.
Interbed gaps	May underestimate risk	If gaps occurred at key places, risk would be underestimated.
Low permeability zone in aquifer	May overestimate risk	Without it, the dilution would be much greater.
Estimating the mass of contaminants in soils by assuming an average contamination concentration for the surface soils	May underestimate risk	This ignores potential soil hot spot risks and computes an average exposure. The procedure is compatible with assuming a long-term average exposure and using chronic toxicity values.
Chemical form assumptions	May Overestimate or underestimate risk	In general, the methods and inputs used in contaminant migration calculations, including assumptions made about the chemical forms of contaminants, were chosen to err on the protective side. This assumption results in a probable overestimate of risk.

Table 6-8. (continued).

Uncertainty Factor	Effect of Uncertainty	Comment
Exposure scenario assumptions	May overestimate risk	The likelihood of future scenarios has been qualitatively evaluated as improbable for residential and credible for industrial. The likelihood of future residential development at the Subsurface Disposal Area (SDA) is small. If future residential use of the SDA does not occur, then future residential risk estimates are likely to overestimate the actual risk associated with future use of the SDA.
Exposure parameter assumptions	May overestimate risk	Assumptions about media intake, population characteristics, and exposure patterns may not characterize actual exposures.
Receptor locations	May overestimate risk	Groundwater ingestion risks are calculated using maximum concentrations. Other well locations would show lower risks.
Exposure duration	May overestimate risk	The assumption that an individual will work or reside at the SDA for 25 or 30 years is conservative. Short-term exposures involve comparison to subchronic toxicity values, which are generally less restrictive than chronic values.
Exclusion of some hypothetical pathways from the exposure scenarios	May underestimate risk	Exposure pathways are considered for each scenario and are eliminated only if the pathway is either incomplete or negligible compared to other evaluated pathways.
Not considering biotic decay	May overestimate or underestimate	Biotic decay would tend to reduce contamination over time. However, decay products could be produced that are as toxic as the parent product.
Use of occupational intake value for inhalation for occupational and residential scenarios	May slightly overestimate risk	Standard exposure factors for inhalation conservatively have the same value for occupational as for residential scenarios, though occupational workers would not be on site all day.
Use of cancer slope factors	May overestimate risk	Slope factors for chemicals are associated with upper-95th-percentile confidence limits. It is likely that their use would result in overestimating actual risk. For radionuclides, slope factors are maximum likelihood estimates, so represent a best estimate for the dose response assuming a linear effect at low exposure levels.

Table 6-8. (continued).

Uncertainty Factor	Effect of Uncertainty	Comment
Toxicity values derived primarily from animal studies	May overestimate or underestimate risk	Extrapolation from animals to humans may induce error caused by differences in absorption, pharmacokinetics, target organs, enzymes, and population variability.
Toxicity values derived primarily from high doses while most exposures are at low doses	May overestimate or underestimate risk	Linearity is assumed at low doses. Exposure assumptions tend to be conservative.
Toxicity values and classification of carcinogens	May overestimate or underestimate risk	Not all values represent the same degree of certainty. All are subject to change as new evidence becomes available.
Lack of slope factors	May underestimate risk	Contaminants of potential concerns (COPCs) without slope factors may or may not be carcinogenic through the oral pathway.
Lack of reference doses	May underestimate risk	COPCs without reference doses may or may not have noncarcinogenic adverse effects.
Risks and hazard quotients summed across pathways	May overestimate or underestimate risk	Synergistic or antagonistic effects of mixtures of contaminants are ignored.
Inadequate toxicity or inventory information to quantify risk for nine contaminants	May underestimate risk	Nine contaminants that were qualitatively evaluated in the Interim Risk Assessment (Becker et al. 1998) were retained for further analysis depending on the additional availability of toxicity or inventory data. Because additional data have not become available, these contaminants were not evaluated. The nine contaminants are chloroform, dibutylethylcarbutol, nitrocellulose, organic acids, organophosphates, toluene, trichloroethylene, 1,1,1-trichloroethane, and xylene.

Table 6-9. Sensitivity cases addressed.

Uncertainty addressed	Base Case	Cases Simulated
Inventory amounts	Best-estimate inventory	Upper-bound inventory for all contaminants
Plutonium mobility	K_d of 5,100	K_d values of 22, 320, and 1,700 for plutonium in Groups 2 and 4
Plutonium mobility	No mobile fraction assumed	Mobile fractions of 1E-2, 1E-4, and 1E-6 for plutonium in simulation Groups 2 and 4
Uranium solubility	Uranium solubility of 5.98E-4 g/cc	Uranium solubility of 9.3E-7 g/cc and 9.3E-11 g/cc for Group 5
Neptunium solubility	Neptunium solubility of 7.49E-8 g/cc	Neptunium solubility of 1.3E-11 g/cc and 1.2E-6 g/cc
Spreading area influence	Attempted to match observed effect	No influence and double the base-case influence
Effect of spatial infiltration	Spatially variable infiltration	Uniform infiltration of 8.5 and 23 cm/yr
Gaps in the B-C interbed	Continuous interbeds, narrow in places; kriged lithology used	Known gaps in the B-C interbed simulated

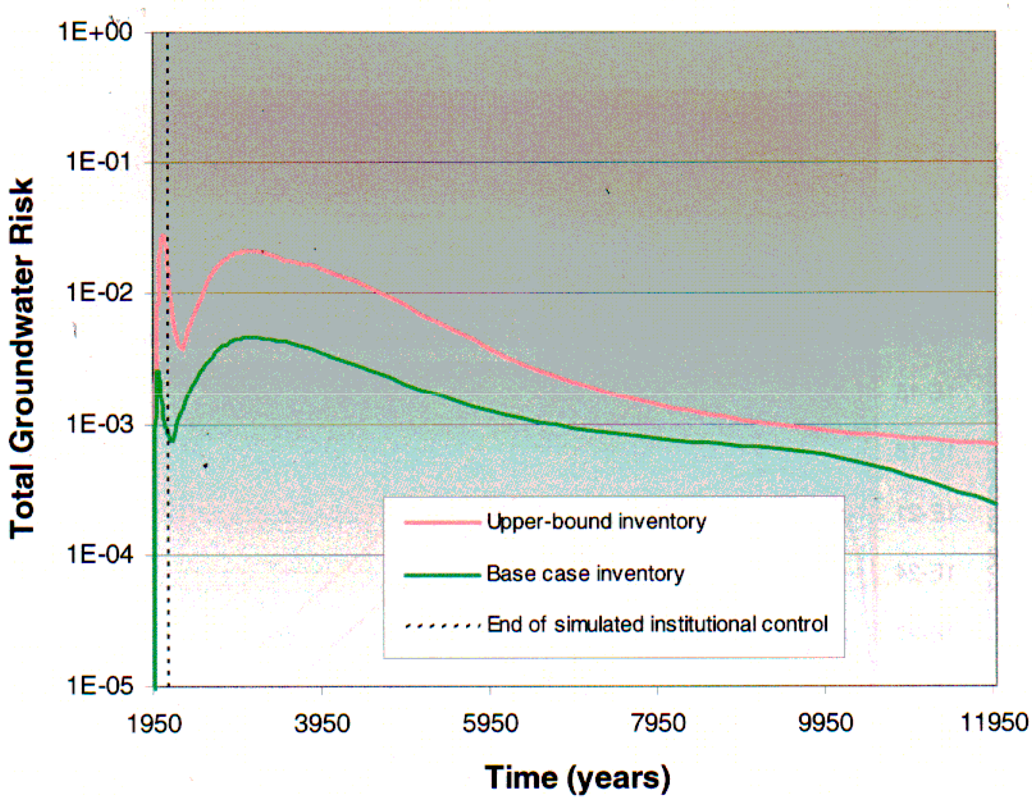

Figure 6-83. Comparison of the estimated groundwater ingestion risk for the best-estimate and upper-bound inventories.

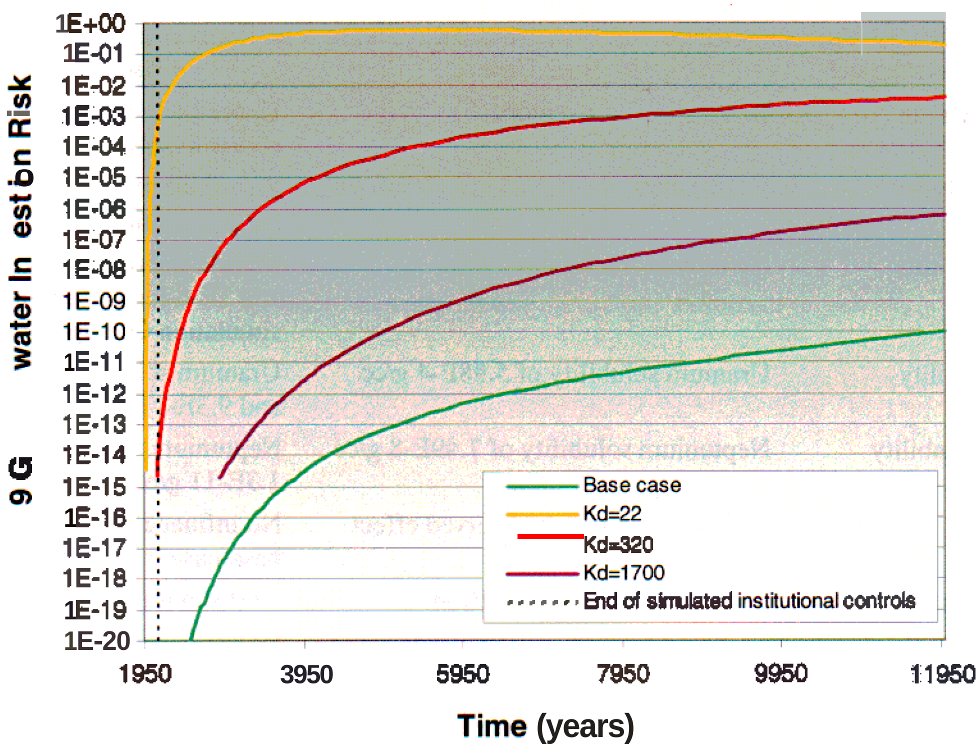

Figure 5-84. Comparison of the estimated plutonium-239 groundwater ingestion risks for plutonium mobility sensitivity cases.

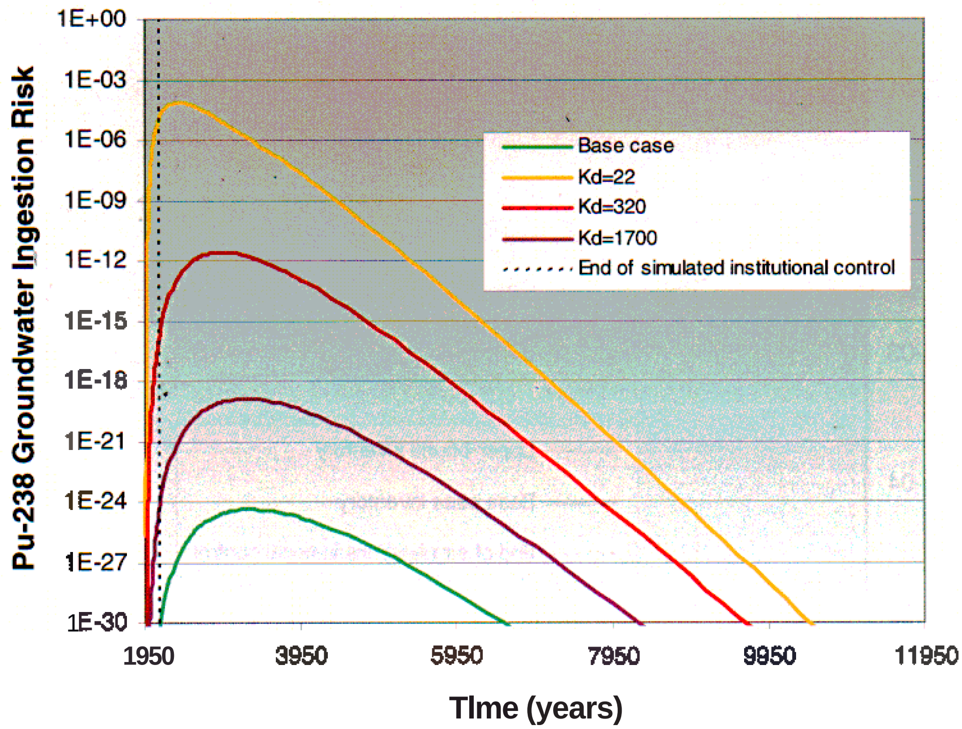

Figure 6-85. Comparison of the estimated plutonium-238 groundwater ingestion risk for plutonium mobility sensitivity cases.

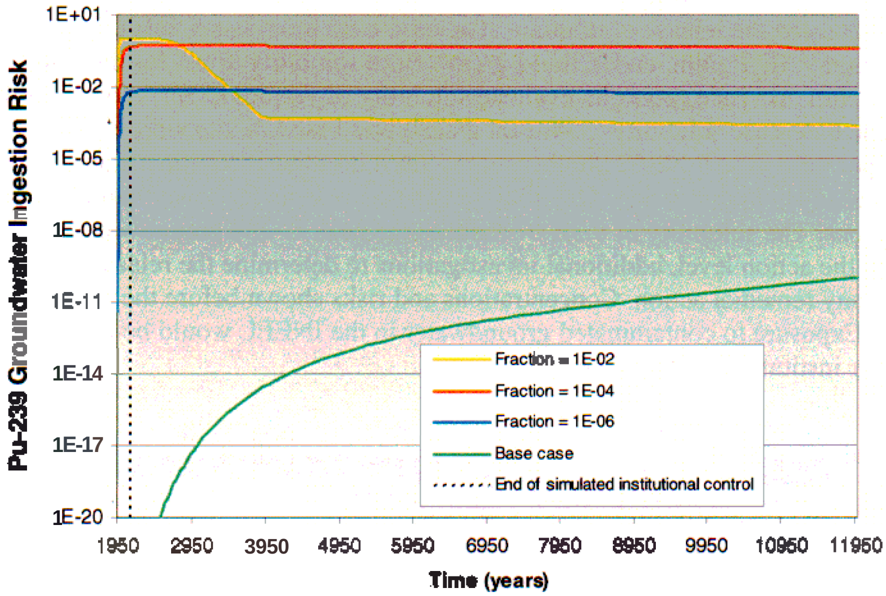

Figure 6-86. Comparison of the estimated plutonium-239 groundwater ingestion risk for mobile fraction sensitivity.

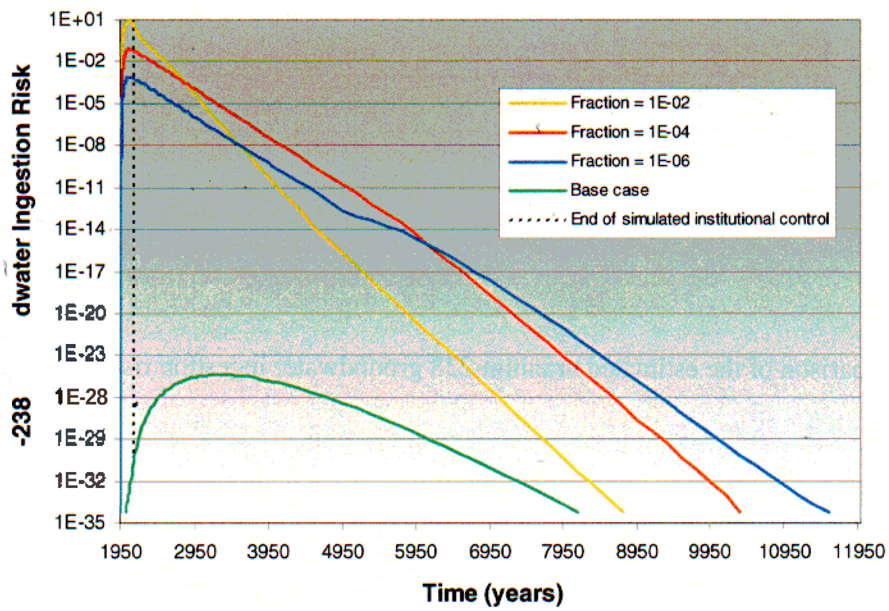

Figure 6-87. Comparison of the estimated plutonium-238 groundwater ingestion risk for mobile fraction sensitivity.

6.5.3.2.3 ***Uranium Release Rates***—Two different solubility limits were simulated to address the uncertainty in the release of uranium. The base-case limit was 5.98E-04 g/cm^3, and the sensitivity cases used 9.357 g/cm^3 and 9.3E-11 g/cm^3. Both solubility limits for the sensitivity runs were based on work by Hull and Pace (2000) to evaluate solubility of various COPCs for different redox and pH conditions. The base-case solubility (5.98E-04 g/cm^3) was based on the work by Dicke (1997) and is considered an upper limit. The 9.3E-07 number represents a best guess for the pH and redox conditions assumed in the waste (see Figure 6-88). The 9.3E-11 limit represents the lower bound for reasonable Eh and pH combinations. The solubility of 9.3E-07 reduces the peak U-238 groundwater ingestion risk to 9E-05. If 1E-04 is the action level, additional investigations to determine the release of U-238 could result in cost savings in any remedial action. Concentrations and risks shown before the year 2110 are for comparison only. Exposure to contaminated groundwater in the INEEL would be prevented during the simulated 100-year institutional control period.

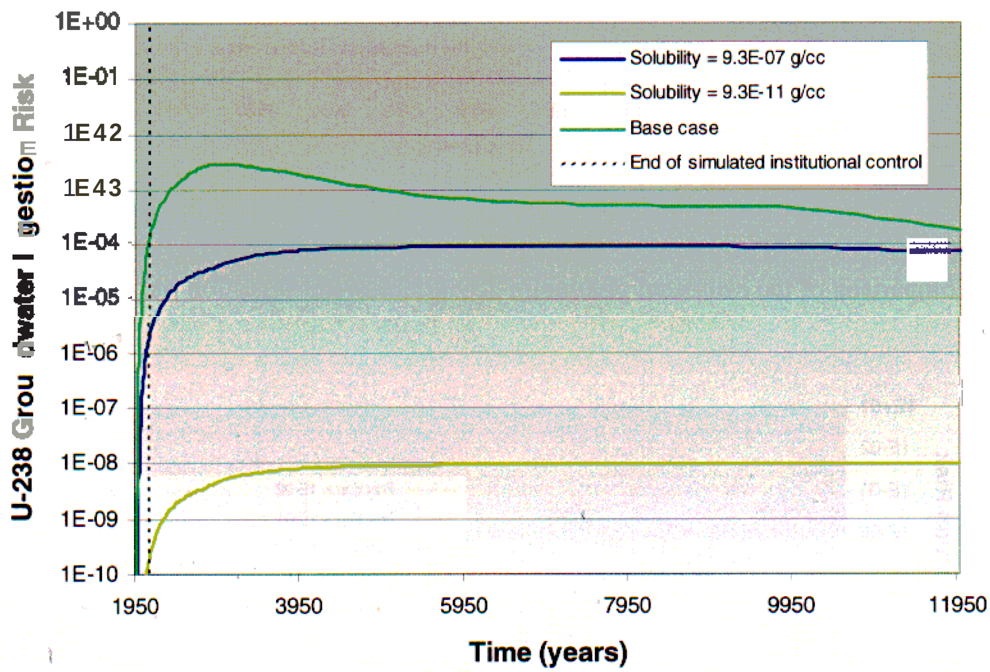

Figure 6-88. Comparison of the estimated uranium-238 groundwater ingestion risk for selected uranium solubility:

6.5.3.2.4 *Neptunium Release*—Solubility limits were modified to address uncertainties in the release of Np-237. As with the uranium, new limits were based on work by Hull and Pace (2000). The base solubility of 7.49E-08 g/cm^3 corresponds to the average conditions presented in Hull and Pace (2000). Upper and lower bounds were simulated to determine the effect on the Np-237 risk from groundwater ingestion. Figure 6-89 shows the comparison with the base case. The base case and the 1.2E-06 solubility limit overlay each other, indicating that neither one limits release of the Np-237. Concentrations and risks shown before the year 2110 are for comparison only. Exposure to contaminated groundwater in the INEEL would be prevented during the simulated 100-year institutional control period.

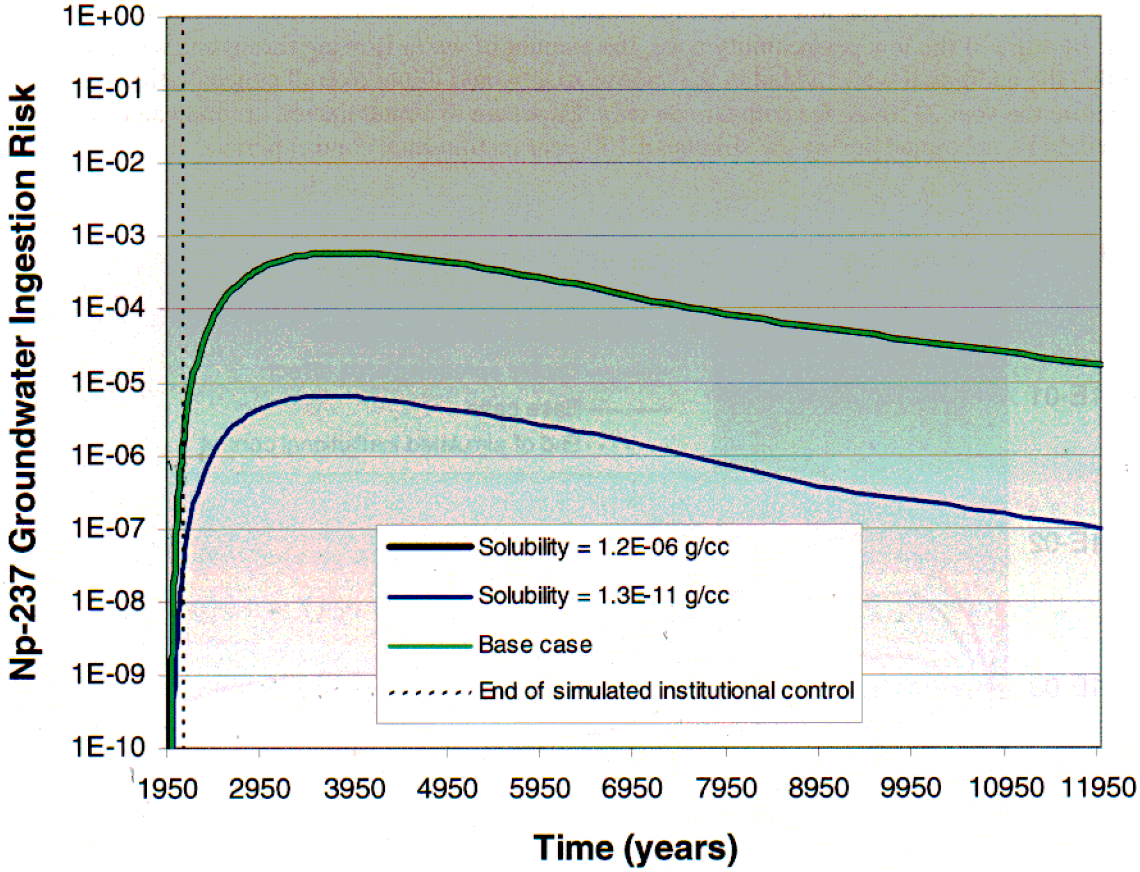

Figure *6-89.* Comparison of the estimated neptunium-237 groundwater ingestion risk for neptunium solubility sensitivity cases.

6.5.3.2.5 Spreading Area Influence—The effect of the spreading areas on fate and transport was included in the base case simulations because of work performed by the USGS (Nimmo et al. 2002) showing that a tracer put in the spreading area has been detected in the subsurface beneath the SDA. While data were not sufficient to calibrate the flow model, some indication of the effect of the spreading areas was seen in the tracer measured in the subsurface beneath the SDA. The influence of the spreading areas simulated for the ABRA included a water source that came part way across the SDA at the C-D interbed. To address the uncertainty in the amount of water impacting the transport of contaminants, no water in the spreading area, and twice the amount of water used in the base case were simulated, Figure 6-90 presents the results of those simulations. The effect of the spreading area is to introduce additional water in the subsurface, which dilutes contaminants before they reach the aquifer. Part of the reason for this is the low permeability zone in the aquifer beneath and immediately south of the SDA. Because of the low permeability zone, the amount of water flowing through this region is low enough that the additional water added in the vadose zone would dilute overall concentrations. Risks shown before the year 21 10 are for comparison only. Exposure to contaminated groundwater in the INEEL would be prevented during the simulated 100-year institutional control period.

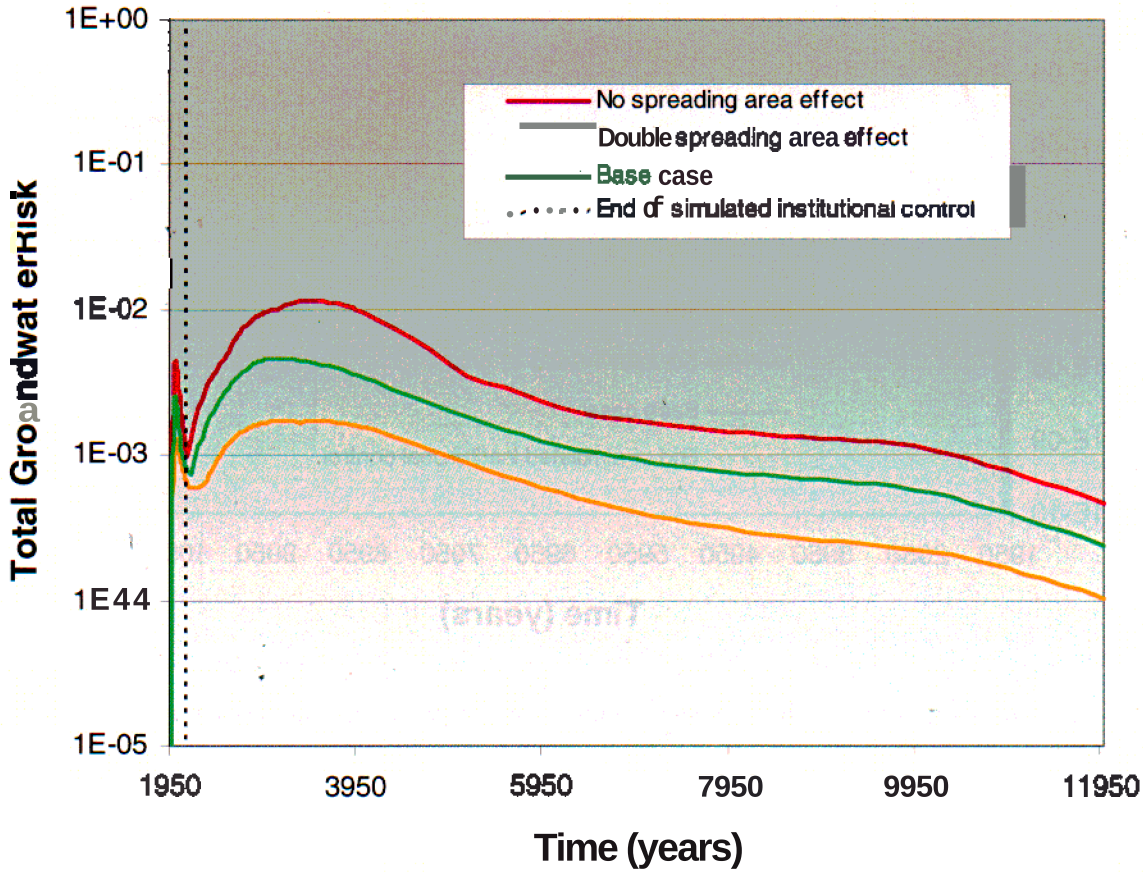

Figure 690. Comparison of the estimated total groundwater ingestion risk for spreading area influence sensitivity cases.

6.5.3.2.6 ***Effect of Spatially Variable Infiltration***—To assess the effects of average and maximum infiltration, two additional simulations were run. Results are presented in Figure 6-91, which shows that increased infiltration increases the peak risk and causes the peak to occur sooner. Using the average infiltration rate increases the risk by a factor of 2, because more water is going through grid blocks that represent waste zones in the model. This demonstrates the sensitivity of risk to the infiltration through the waste and the need for measuring infiltration rates in the waste zone. Risks shown before the year 2110 during the simulated 100-year institutional control period are shown only to compare the effect of the variation in infiltration rates.

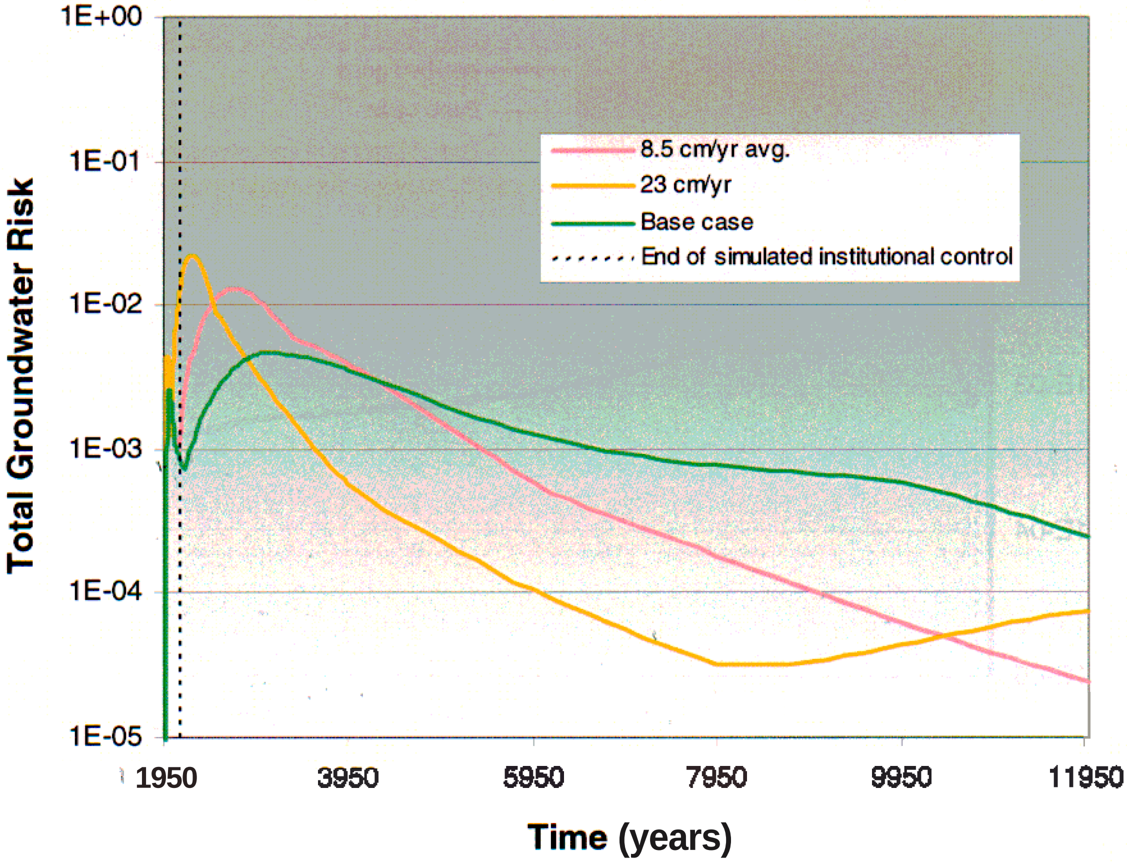

Figure 6-91. Comparison of the estimated total groundwater ingestion risk for infiltration rates sensitivity cases.

6.5.3.2.7 ***Gaps in the B-C Interbed***—Gaps in the B-C interbed were simulated to address the potential effect on overall risk. The base case used the kriged lithology (Leecaster 2002) that had narrow interbeds, but no actual gaps were included. Results are presented in Figure 6-92, showing that modeling gaps in the interbeds have little effect on the total risk. Risks shown before the year 2110 are for comparison only. Exposure to contaminated groundwater in the INEEL would be prevented during the simulated 100-year institutional control period.

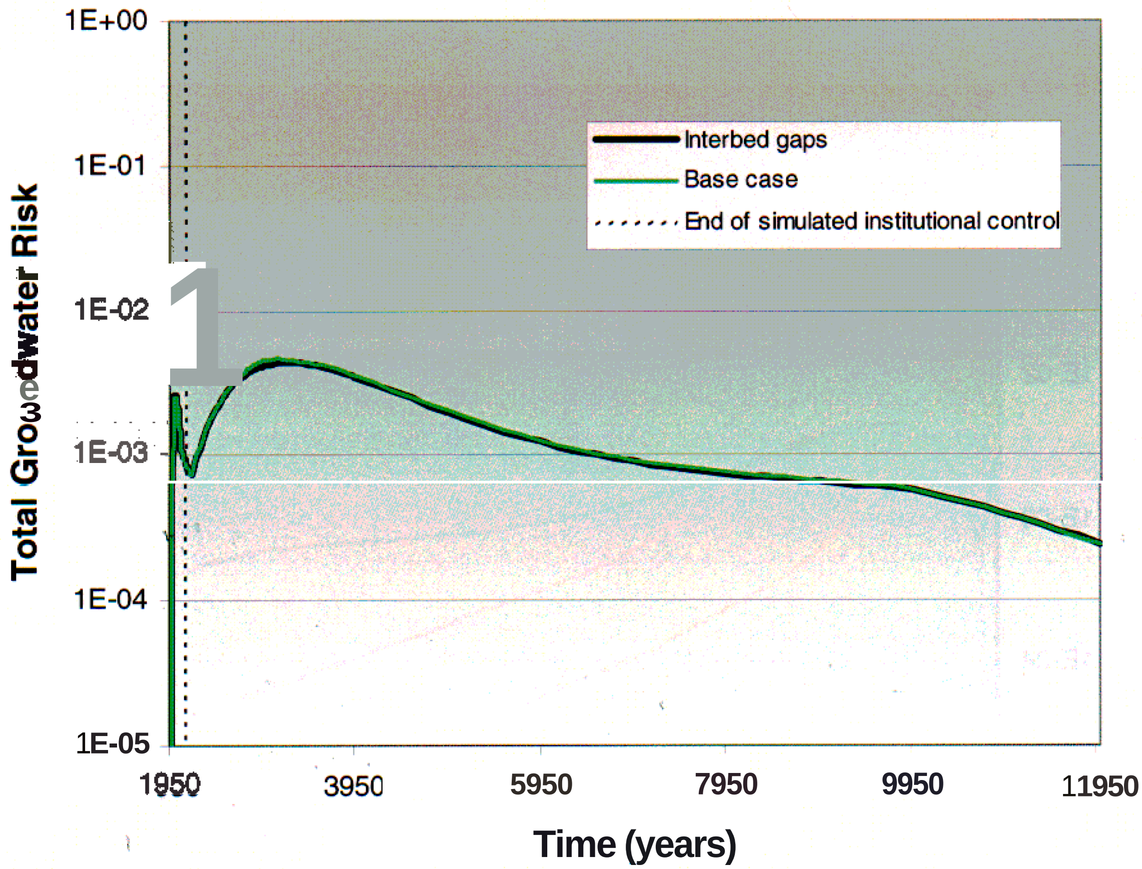

Figure 6-92. Comparison of the estimated total groundwater ingestion risk for the B-C interbed gaps sensitivity case.

6.5.3.2.8 *Effect of Inventory Uncertainty on Technetium-99 Risk*—Estimated concentrations of Tc-99 are higher compared to the relatively low measured concentrations in the aquifer (see Section 5.2). A large fraction of the inventory of Tc-99 is attributed to disposals of INEEL reactor operations waste, including limited amounts of spent fuel. The inventory is still under review (see Section 3.3), and the actual release rates are unknown. To bound the risk, it was assumed for the base case that the release of contaminants from reactor operations waste was not retarded by any type of containment (e.g., cladding and metal casks). Therefore, Tc-99 was released by the surface washoff release mechanism with a low K_d in the DUST-MS code. Because Tc-99 is a fission product in the fuel, Tc-99 would not be released until the fuel dissolved. Fuel dissolution rates were identified in the literature and used to determine what might be a more representative release rate. However, a large overprediction of the measured concentrations was still the result. The fraction of Tc-99 in fuel was then modeled as contained and not available for release. Figure 6-93 shows the effect of these permutations on the risks produced. Further work to better define the inventory and release rate would improve the risk assessment results, Risks shown before the year 2110 are for comparison only. Exposure to contaminated groundwater in the INEEL would be prevented during the simulated 100-year institutional control period.

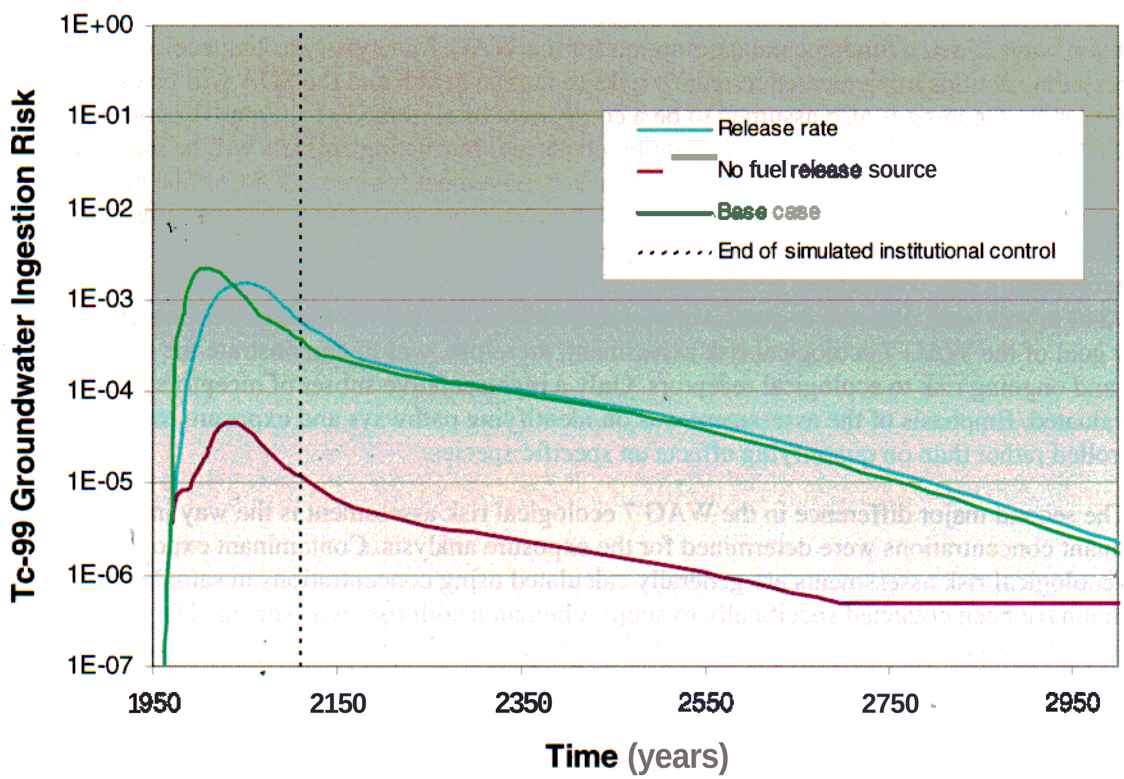

Figure 6-93. Comparison of the estimated technetium-99 groundwater ingestion risk for differing release rates for Idaho National Engineering and Environmental Laboratory reactor operations waste disposal sensitivity cases.

6.6 Ecological Risk Assessment

6.6.1 Introduction

An ecological risk assessment evaluates risks to ecological resources from potential exposure to radiological and nonradiological contaminants at WAG 7. Preliminary screenings were conducted to identify those contaminants that have the potential to cause adverse ecological effects. Risks to ecological receptors posed by the WAG 7 COPCs identified in those screenings have been analyzed in this subsection.

The approach for performing ecological risk assessments at the INEEL was specifically designed to follow the EPA ***Framework for Ecological Risk Assessment*** (EPA 1992b), which is divided into three steps: problem formulation, analysis, and risk characterization. The present assessment was also performed using the same general methodology developed in the INEEL guidance manual (VanHorn, Hampton, and Morris 1995). However, some aspects of the methodology were modified to allow a limited evaluation of ecological risk rather than a complete ecological risk assessment.

The WAG 7 ecological risk assessment differs from other WAG-level ecological risk assessments in two main ways. First, a fundamental assumption for the WAG 7 analysis was that ecological risk will be addressed by actions implemented to reduce risks to human health and the SDA will be capped (DOE-ID 1998). Capping is also assumed to be a component of all remedial alternatives considered in the FS (DOE-ID 1998). Intrusion into buried waste by plants and burrowing animals will be impeded by a biological barrier, thus controlling subsurface-to-surface movement for most COPCs. The presumption that ecological receptors may be exposed to WAG 7 contaminants is based on observed trends in biotic data collected in the RWMC area (Peterson, Brewer, and Morris 1995). For example, concentrations above ecologically based screening levels for Cs-137 and Sr-90 in animal tissue and for Pu-238 and Pu-239/240 in soil were detected in some samples collected in and around the SDA before 1987. The primary goal of the WAG 7 ecological risk assessment, therefore, was to demonstrate the existence of current and ongoing risk to ecological receptors. Only a representative subset of receptors and COPCs were evaluated. Emphasis of the assessment was on identifying pathways and exposure routes that must be controlled rather than on quantifying effects on specific species.

The second major difference in the WAG 7 ecological risk assessment is the way in which media contaminant concentrations were determined for the exposure analysis. Contaminant exposures for INEEL ecological risk assessments are generally calculated using concentrations in samples from various media that have been collected specifically to support human health risk assessments. Contact with and ingestion of contaminated soil are the primary routes of exposure for ecological receptors on the SDA. However, soil samples collected on the SDA were taken largely from areas between pits and trenches. Soil cover on the SDA has also been increased and recontoured several times since most samples were collected, so measured concentrations may not reasonably represent current or future concentrations.

As an alternative to sampling data, the DOSTOMAN model was used to produce surface and subsurface soil concentrations for the WAG 7 human health risk assessment (see Section 6.4). Modeling also allowed evaluating changes in concentrations over time, so long-term scenarios associated with potential transport of buried waste could be assessed. Concentrations were modeled for a suite of contaminants that are of potential concern for both human and ecological receptors. The modeled surface and subsurface concentrations were then used to evaluate potential receptor exposure in the ecological risk assessment. The assumptions and uncertainties associated with the treatment of sampling data and use of modeled concentrations in the human health assessment also apply for the ecological risk assessment.

Traditional measurement and assessment endpoints also were not defined for this assessment. Rather, the indication of risk represented by HQs was used to meet the objectives of this assessment, which are to:

- Provide evidence that clearly demonstrates the need to protect ecological receptors
- Provide a preliminary basis for cap design features and cap performance criteria.

The problem formulation part of the ecological risk assessment consists of a brief ecological characterization of WAG 7 (see Section 6.6.2), identification of COPCs (see Section 6.6.3), and identification of pathways and receptors that were evaluated (see Section 6.6.4). The analysis portion of the assessment is presented in Section 6.6.5, where risk is estimated for representative COPCs and receptors. Risk characterization (see Section 6.6.6) is focused on potential exposures to threatened or endangered species and receptors targeted for protection by capping (i.e., burrowing species, plants, and herbivores). Existing biotic and soil sampling data were used to support a qualitative corroboration and characterization of calculated exposure.

6.6.2 Waste Area Group 7 Ecological Characterization

6.6.2.1 Flora and Fauna. Most of the SDA has been seeded with crested wheatgrass (Agropyron *cristatum*) to reduce moisture infiltration and erosion. Weedy species such as Russian thistle (*Salsola kali*) and summer cypress (*Kochia* scoparia) have invaded disturbed areas that have not been seeded successfully with grass. Areas surrounding the SDA support native communities dominated by sagebrush ***(Artemisia** tridentata*), with large components of green rabbitbrush (*Chrysothamnus viscidiflorus*) and bluebunch wheatgrass (Pseudoroegneria spicata).

The SDA has been the site of numerous ecological investigations conducted to evaluate the role of plants and animals in the transport of subsurface contamination to surface receptors and through the food web. Most of the biotic studies conducted at the INEEL have focused on exposures of biota to radioactive contaminants. Sampling and analysis results for biota associated with the SDA are detailed in Section 4.9.

Fauna potentially present at WAG 7 are those species supported by the various vegetation communities that exist at and around the facility. Nearly all avian, reptile, and mammalian species found across the INEEL also could be found at WAG 7. Arthur and Markham (1978) conducted ecological studies that included the investigation of vegetation and animals on and around the SDA. A list of birds and mammals observed during those studies is given in Table 6-10. This list is not exhaustive. Numerous other bird species have been identified during breeding bird surveys that are regularly conducted along a permanent route outside the perimeter of WAG 7. Many other species (e.g., pronghorn, porcupine, marmot, and sagebrush lizard) have been observed in the area.

Burrowing rodents (e.g., ground squirrels and mice) and insects (e.g., harvester ant [*Pogonomyrmex salinus*]) are common WAG 7 inhabitants. Several studies have included the investigation of community compositions, densities, and habitat use in and around the SDA for small mammals (Groves 1981; Groves and Keller 1983; Koehler 1988; Boone 1990; Boone and Keller 1993). Those studies identified Townsend's ground squirrel (Spermophilus ***townsendii*),** Ord's kangaroo rat (*Dipodomys* ***ordii*),** montane vole (Microtus *montanus*), and the deer mouse (*Peromyscus* maniculatus) as the most commonly occurring small mammals in the WAG 7 assessment area. Larger mammals (e.g., coyotes and antelope) generally are excluded from the SDA and other facility structures by fences, but occasionally are seen on facility grounds. No ecologically sensitive areas (i.e., areas of critical habitat) have been identified in WAG 7.

Table 6-10. Species observed in habitats in and around the Waste Area Group 7 assessment area.

Observed Species[a]	Taxonomic Name
House sparrow	***Passer domesticus***
Mourning dove	***Zenaida macroura***
Chukar	***Alectoris chukar***
Sage grouse	***Centrocercus urophasianus***
Horned lark	***Eremophila alpestris***
Dark-eyed junco	***Junco hyemalis***
Northern flicker	***Colaptes auratus***
European starling	***Sturnus vulgaris***
Sage thrasher	***Oreoscoptes montanus***
Sage sparrow	***Amphispiza belli***
Western meadowlark	***Sturnella neglecta***
Killdeer	***Charadrius vociferous***
Yellow-headed blackbird	***Xanthocephalus xanthocephalus***
Merlin	***Falco columbarius***
American kestrel	***Falco sparverius***
Northern harrier	***Circus cyaneus***
Loggerhead shrike	***Lanius ludovicianus***
Great horned owl	***Bubo virginianus***
Long-eared owl	***Asio otus***
Golden eagle	***Aquila chrysaetos***
Rough-legged hawk	***Buteo lagopus***
Black-billed magpie	***Pica pica***
Black-tailed jackrabbit	***Lepus californicus***
Mule deer	***Odocoileus hemionus***
Nuttall's cottontail	***Sylvilagus nuttallii***
Pygmy rabbit	***Brachylagus idahoensis***
Long-tailed weasel	***Mustela frenata***
Badger	***Taxidea taxus***
Bobcat	***Felis rufus***
Covote	***Canis latrans***

a. This information was taken from Arthur and Markham (1978).

The concept of functional grouping has also been incorporated in this assessment. The functional grouping approach is designed to allow the evaluation of the effects of stressors on groups of similar species. The primary purpose for functional grouping is to apply existing data from one or more species within the group to assess the risk to the group as a whole. Functional groups were developed as a tool for conducting screening-level analyses in the absence of site-specific biotic and contaminant data. Simplistic screening models (see Appendix D, DOE-ID 1999b) were used to perform a limited evaluation of exposures for a suite of potential receptors and provide a mechanism for focusing on receptors that best characterize potential Contaminant effects. The concept of functional grouping is described in detail in Appendix E of Van Horn, Hampton, and Morris **(1995).**

Functional groups evaluated in the WAG 7 ecological assessment are conservative indicators of effects for all species in each group. Species characteristics, including trophic level, breeding, and feeding locations, were used to construct functional groups for INEEL species. Individual groups were assigned a unique identifier consisting of a one- or two-letter code to indicate taxon (i.e., A = amphibians, AV = birds, M = mammals, R = reptiles, and I = insects), and a three-digit code derived from the combination of trophic category and feeding habitats (e.g., **AV122** represents the group of seed-eating [herbivorous] bird species whose feeding habitat is the terrestrial surface or understory). The trophic categories are indicated by the first digit in the three-digit code and are as follows:

1 = herbivore, **2** = insectivore, **3** = carnivore, **4** = omnivore, and 5 = detrivore. The feeding habitat codes are the second and third digits in three-digit code and are derived as follows:

- **1.0** Air
- **2.0** Terrestrial
  - **2.1** Vegetation canopy
  - **2.2** Surface and understory
  - **2.3** Subsurface
  - **2.4** Vertical habitat (man-made structures and cliffs)
- **3.0** Terrestrial and aquatic interface
  - **3.1** Vegetation canopy
  - **3.2** Surface and understory
  - **3.3** Subsurface
  - **3.4** Vertical habitat
- **4.0** Aquatic
  - **4.1** Surface water
  - **4.2** Water column
  - **4.3** Bottom

Individual species are evaluated using the same exposure models as those for functional groups. However, species modeled in this manner represent neither conservative representatives of the functional groups with which they are associated nor accurately represent species characteristics. Rather, an individual species model gives an estimate of risk relative to different species within the same functional group.

6.6.2.2 Threatened, Endangered, and Sensitive Species. A list of threatened or endangered (T/E) and sensitive species that may occur on the INEEL is given in Table **6-11**. The list was most recently updated in February **2002** using information contained in USFWS **(2001).**

The only species documented at the INEEL and currently recognized as threatened or endangered under the Endangered Species Act is the bald eagle, which was recently down-listed to threatened. The peregrine falcon, recently removed from the federal T/E list, remains on the endangered species list for the State of Idaho.

Table 6-11. Threatened or endangered species, sensitive species, and species of concern that may be found at the Idaho National Engineering and Environmental Laboratory.

Common Name[a]	Scientific Name	Federal Status[b,c]	State Status'	Bureau of Land Management Status'	United States Forest Service' Status'
Plants					
Lemhi milkvetch	*Astragalus aquilonius*	—	S	S	S
Painted milkvetch[e]	*Astragalus ceramicus var. apus*	SC	R	—	—
Plains milkvetch	*Astragalus gilviflorus*	—	1	S	S
Winged-seed evening primrose	*Camissonia pterosperma*	—	S	S	—
Nipple cactus[e]	*Escobaria (=Coryphantha) missouriensis*	—	R	—	—
Spreading gilia	*Ipomopsis (=Gilia) polycladon*	—	2	S	—
King's bladderpod	*Lesquerella kingii var. cobrensis*	—	M	—	—
Tree-like oxytheca[e]	*Oxytheca dendroidea*	—	R	R	—
Inconspicuous phacelia[d]	*Phacelia inconspicua*	C	SSC	S	S
Ute ladies' tresses[d]	*Spiranthes diluvialis*	LT	—	—	—
Puzzling halimolobos	*Halimolobos perplexa var. perplexa*	—	M	—	S
Slender moonwort[d]	*Botrychium lineare*	R	GP1	—	—
Birds					
Peregrine falcon	*Falco peregrinus*	R	E	—	—
Merlin	*Falco columbarius*	—	P	S	—
Gyrfalcon	*Falco rusticolus*	—	SSC	S	—
Bald eagle	*Haliaeetus leucocephalus*	LT	T	—	—
Ferruginous hawk	*Buteo regalis*	W	SSC	S	—
Black tern	*Chlidonias niger*	—	SSC	—	—
Northern pygmy owl[d]	*Glaucidium gnoma*	W	SSC	—	—
Burrowing owl	*Athene (=Speotyto) cunicularia*	SC	—	S	—
Common loon	*Cavia immer*	W	SSC	—	—
American white pelican	*Pelicanus erythrorhynchos*	—	SSC	—	—
Great egret	*Casmerodius albus*	—	SSC	—	—
White-faced ibis	*Plegadis chihi*	SC	—	—	—
Long-billed curlew	*Numenius americanus*	SC	—	S	—
Loggerhead shrike	*Lanius ludoviciunus*	SC	NL	S	—
Northern goshawk	*Accipiter gentilis*	W	P	—	S
Swainson's hawk	*Buteo swainsoni*	—	—	S	—
Trumpeter swan	*Cygnus buccinator*	SC	SSC	S	S
Sharptailed grouse	*Tympanuchus phasianellus*	SC	—	S	S
Boreal owl	*Aegolius funereus*	W	SSC	S	S
Flammulated owl	*Otus flammeolus*	W	SSC	—	S
Yellow-billed cuckoo[d]	*Coccyzus americanus*	C	—	—	—

Table 6-11. **(continued).**

Common Name[a]	Scientific Name	Federal Status[b,c]	State Status‘	Bureau of Land Management Status‘	United States Forest Service Status‘
Birds (continued).					
Greater sage grouse	***Centrocercus urophasianus***	SC	—	—	—
Mammals					
Gray wolf[g]	***Canis lupus***	LE/XN	E	—	—
Pygmy rabbit	***Brachylagus (=Sylvilagus) idahoensis***	**W**	***GSC***	**S**	**—**
Townsend's Western big-eared bat	***Corynorhinus (=Plecotus) townsendii***	**SC**	**SSC**	**S**	**S**
Merriam's shrew	***Sorex merriami***	—	U	—	—
Long-eared myotis	***Myotis evotis***	W	U	—	—
Small-footed myotis	***Myotis ciliolabrum (=subulatus)***	W	U	—	—
Western pipistrelle[d]	***Pipistrellus hesperus***	W	SSC	—	—
Fringed myotis[d]	***Myotis thysanodes***	W	SSC	—	—
California myotis[d]	***Myotis californicus***	W	U	—	—
Reptiles and amphibians					
Northern sagebrush lizard[h]	***Sceloporus gracwsus***	**SC**	—	—	—
Ringneck snake[d]	***Diadophis punctatus***	C	SSC	*S*	—
Night snake‘	***Hypsiglena torquata***	—	—	R	—
Insects					
Idaho pointheaded grasshopper[d]	***Acrolophitus punchellus***	W	—	—	—
Fish					
Shorthead sculpin[d]	***Cottus confusus***	—	SSC	—	—

a. This list was compiled by N. Hampton (INEEL) from letters issued by the U.S. Fish and Wildlife Service (USFWS) (1996, 1997, 1999, 2001) for threatened or endangered, and sensitive species listed by the Idaho Department of Fish and Game (IDFG) Conservation Data Center (CDC 1994 and IDFG website 1997, 2002) and Radiological Environmental Sciences Laboratory documentation for the INEEL (Reynolds et al. 1986).
b. The USFWS no longer maintains a candidate (C2) species listing but addresses former listed species as "species of concern" (USFWS 1996). Species that are current candidates for listing are designated by C.
c. Status codes: INPS=Idaho Native Plant Society; S=sensitive; 2=State Priority 2 (INPS); M=State of Idaho monitor species (INPS); U= undetermined, 1=State Priority 1 (INPS); LE=listed endangered; P=protected nongame species, E=endangered; T = threatened; XN = experimental population, nonessential; SC=species of concern, SSC=species of special concern; W = watch species and C = candidate for listing, see item b, formerly Category 2 (defined in CDC 1994). BLM=Bureau of Land Management; R = removed from sensitive list (nonagency code added here for clarification).
d. No sightings have been documented sightings at the INEEL; however, the ranges of these species overlap the INEEL and are included as possibilities to be considered for field surveys.
e. Recent updates that resulted from Idaho State Sensitive Species meetings (BLM, USFWS, INPS, and USFS) (IDFG website 2002).
f. U.S. Forest Service (USFS) Region 4.
g. Anecdotal evidence indicates that isolated wolves may visit the INEEL, but observed hunting and breeding are not documented (Moms 1999).
h. The sagebrush lizard was placed on the list as a result of a miscommunication (Dr. Charles Peterson, Idaho State University, lecture at Idaho Department of Fish and Game attended by N L. Hampton, INEEL, January 10, 2002, Idaho Falls, ID). However, it remains on the official USFWS T/E update periodically issued for the INEEL (USFWS 2001).

Note: Species in bolded text were individually assessed in the WAG 7 ecological risk assessment.
— = Not applicable.

A number of former C2 species (candidates for listing) recorded at the INEEL no longer have status under the Endangered Species Act, but remain species of concern. These include the burrowing owl ***(Athene*** cunicularia), white-faced ibis (***Plegadis chichi),*** trumpeter swan ***(Cygnus buccinator),*** long-billed curlew ***(Numenius*** americanus), loggerhead shrike ***(Lunius excubitor),*** greater sage grouse ***(Centrocercus urophasianus),*** sharp-tailed grouse ***(Tympanuchus phasianellus***), and Townsend's western big-eared bat *(Corynorhinus* ***townsendii).*** Painted milk-vetch ***(Astragalus*** ceramicus var. ***apus)*** also remains on the USFWS periodic update for the INEEL (USFWS 2001), but has been removed from the State of Idaho list. The sagebrush lizard (***Sceloporous graciosus***) was designated as a candidate for listing through a **miscommunication,**[a] but remains as a species of concern on the periodic T/E species update for the INEEL (USFWS **2001).**

Five additional species documented at the INEEL also appear on the federal watch list and the USFWS list of species of concern for the INEEL (USFWS **2001)** including: the ferruginous hawk ***(Buteo regalis),*** pygmy rabbit ***(Brachylagus idahoensis***), Merriam's shrew ***(Sorex merriami),*** long-eared myotis ***(Myotis evotis),*** and small-footed myotis ***(Myotis ciliolabrum***).

Federally listed species or species of concern with a potential for occurring in the vicinity of **WAG 7** include: the ferruginous hawk ***(Buteo*** regalis), peregrine falcon ***(Falco peregrinus),*** loggerhead shrike ***(Lunius ludovicianus),*** burrowing owl ***(Athene*** cunicularia), bald eagle ***(Hafiaeetus leucocephalus***), pygmy rabbit, Townsend's western big-eared bat, long-eared myotis, small-footed myotis, and sagebrush lizard.

The only surface water present at **WAG** 7 is temporary accumulation from rain and snowmelt. No surface water features associated with contamination exist at **WAG 7.** Consequently, sensitive aquatic species were not included in this assessment. No critical habitat is known to exist in the **WAG 7** assessment area.

Sensitive species for which sightings at or near **WAG 7** have been confirmed include the loggerhead shrike **(Morris 1999;** Arthur and Markham **1978),** pygmy rabbit (Arthur and Markham **1978),** and sagebrush lizard (Morris **1999).** Species of concern that were individually evaluated for direct and indirect exposure to contaminants at **WAG 7** include the bald eagle, peregrine falcon, burrowing owl, loggerhead shrike, pygmy rabbit, Townsend's western big-eared bat, and sagebrush lizard (shown in boldface text in Table **6-11).** Because only contaminant concentrations associated with subsurface soil were analyzed for this assessment, only individual species most likely to receive exposures through routes associated with the subsurface soil pathways were evaluated (see Section **6.6.4.1).** Other sensitive species considered unlikely to receive chronic doses through frequenting **WAG 7** are represented through evaluation of these seven species or the functional group with which they are associated (see Section **6.5.4.1).**

6.6.2.2.1 Threatened ***or*** Endangered Species Field ***Surveys***—During **1997** and **1999,** biological field surveys were conducted to investigate the presence of T/E species in and around **WAG 7.** The surveys were conducted in conjunction with the preparation of OU **10-04** ecological risk assessment (DOE-ID **2001).**

First, a biological survey of the areas surrounding **WAG 7** was conducted in **1997** to investigate the presence of T/E species (Morris **1999).** The occurrence of three sensitive species, the pygmy rabbit, loggerhead shrike, and sagebrush lizard, was confirmed during that survey and the potential for the

a. Dr. Charles Peterson, Idaho State University, lecture at Idaho Department of Fish and Game attended by N L. Hampton, INEEL, January 10, 2002, Idaho Falls, ID.

presence of other T/E or sensitive species was evaluated. The complete results and survey methodology are documented in Morris (1999).

Second, an on-site inspection was conducted and each site of contamination was evaluated for habitat qualities and potential to support INEEL T E species or other species of concern. A suite of site habitat attributes was evaluated with regard to suitability for each species. The attributes evaluated included:

- Size
- Substrate (gravel, asphalt, and lawn)
- Natural or anthropic features that entice wildlife (water or lights)
- Proximity to areas or sites of facility activity
- Presence and availability of food or prey
- Availability of nesting, roosting, or loafing habitat
- Signs of wildlife use
- Prior history, known sightings, or use.

Attributes were subjectively rated for positive contribution to overall habitat suitability. A rating of high, medium, low, or none (indicated by a blank cell) was assigned based on the number of positive habitat features and probability that the species of concern may or does use the site of contamination. The conventions used to assign ratings for individual habitat attributes are summarized in Table 6-12. Though T/E and species of concern were of primary consideration, potential use by game species and unique populations (i.e., spadefoot toad and Merriam's shrew) was also assessed. Sites rated overall as low are those having one or two positive attributes and, therefore, potential for incidental use by wildlife. These sites may generally be discounted as contributing significantly to the chronic exposure of wildlife to contaminated media. The duration and stringency of these surveys were not adequate to verify presence or frequency of species occurrence. These surveys were conducted to provide information to allow evaluation of WAG sites of concern in an ecological context. These ratings are subjective and largely based on the professional opinion of field biologists and ecologists and are supported by limited observation. Results of the 1999 survey identified the WAG 7 sites of concern that are summarized in Table 6-13.

Table 6-12. Habitat rating conventions for sites of concern to be evaluated in the Operable Unit 7-13/14 ecological risk assessment.

Attribute	Examples
Size	Physical dimensions of area too small to support species of interest were rated as none unless enhanced by other attributes. Large, unconfined areas adequate to support wildlife were assigned higher ratings.
Substrate	Asphalt = none, gravel =low, lawn and soil = medium to high for some species. Disturbed vegetation community = medium to high, and natural vegetation community = high.
Natural or manmade features	Water = high, lights = medium. Water (permanent or ephemeral) is an important component in desert systems. Water and lights attract insects and, consequently, bats and insectivorous birds (e.g., swallows and nighthawks).
Proximity to areas of activity	Proximity to areas or sites of moderate or heavy human activity may reduce desirability. Sites associated with buildings and facilities may be more suitable if abandoned or are little used.
Nesting, roosting, or loafing habitat	Structures such as fence and power poles adjacent to open fields afford perches for roosting and hunting.
Signs of wildlife use	Signs of wildlife use are considerations that qualitatively feed the evaluation. Examples of these signs include observation of animal tracks, hair, or scat.
Prior history	Documented or reported sightings.

Table 6-13. Summary of the biological field survey for Waste Area Group 7.

Waste Area Group 7 Sites	Black Tern	Trumpeter Swan	White-faced Ibis	Burrowing Owl	Ferruginous Hawk	Peregrine Falcon	Loggerhead Shrike	Bald Eagle	Bats	Merriam's Shrew	Pygmy Rabbit	Sagebrush Lizard	Spadefoot toad	Game	Comments
Subsurface Disposal Area	—	—	—	—	L	M	M	—	—	—	—	L	—	L	Crested wheatgrass has been planted across the Subsurface Disposal Area (SDA) and is mown. Basalt rip-rap runs along the exterior berm. Large rabbitbrush plants grow along the interior and exterior berm edges. Open areas and perches are available for avian hunting. Rodents inhabit the area in and around the SDA. Outside areas provide good sagebrush habitats. Deer have been sighted recently.
Low-Level Waste Pit	—	—	—	—	—	—	—	—	—	—	—	—	—	—	This area includes an open pit, bare soil and gravel, and stacked waste crates.
Transuranic Storage Area	—	—	—	—	—	—	—	—	H	—	—	L	—	—	Buildings have gravel and disturbed areas around and between them plus night lighting, poles, fences, and building roost sites.
Pit 9 complex	—	—	—	—	—	—	—	—	M	—	—	—	—	—	Building and construction material have disturbed soil around and between them plus night lighting, poles, fences, and building roost sites.
Sewage lagoons	L	—	L	—	—	—	—	—	H	—	—	—	M	H	The lagoons contain no contaminants but are in close proximity to the SDA and are not fenced. Native vegetation and basalt outcrops are present in the surrounding area and perches also exist in the vicinity. Ducks, avocet, killdeer, and eared grebes were observed on the lagoons.

Key:
H =high
M= medium
L= low
— = none

See Table 6-12 for examples of rating criteria.

6.6.3 Contaminants of Ecological Concern

Twelve radionuclide and 44 nonradionuclide WAG 7 ecological COPCs were identified in a preliminary screening (Hampton and Becker 2000). Minor revisions to the list were made based on subsequent inventory revisions (see Section 3.3.2). The finalized list of COPCs identified for WAG 7 is presented in Table 6-14.

Table 6-14. Waste Area Group 7 ecological contaminants of potential concern.

Radionuclides	
Am-241	Pu-239
Am-243	Pu-240
Cm-244	Pu-242
Cs-137	Sr-90
Nb-94	U-234
Pu-238	U-238
Nonradionuclides	
1,1,2-trichloro-1,2,2-trifluoroethane	**Nitric acid**
3-methylcholanthrene	Nitrates (total)
Alcohols	**Organophosphates (tributylphosphate)**
Aluminum nitrate	**Organic acids (ascorbic acid)**
Asbestos	Potassium chloride
Beryllium oxide	Potassium hydroxide
Cadmium	Potassium nitrate
Carbon tetrachloride	Potassium phosphate
Chloroform	Potassium sulfate
Dibutylethylcarbutol	Sodium chloride
Ether	**Sodium cyanide**
Ethyl alcohol	**Sodium nitrate**
Hydrazine	Sodium phosphate
Hydroflouric acid	Sodium-potassium
Lead	Sulfuric acid
Lithium hydride	Tetrachloroethylene
Lithium oxide	Trimethylpropane-triester
Manganese	**Toluene**
Magnesium oxide	**Versenes (EDTA)**
Methylene chloride	Xylene
Nitrobenzene	**Copper (total)**
Nitrocellulose	Mercury (total)

Note: Bolded text indicates contaminants for which inadequate data exist to allow further analysis (Hampton and Becker 2000).

6.6.3.1 Nature and Extent of Ecological Contaminants of Potential Concern. No WAG 7 contaminant samples have been collected and analyzed to specifically address ecological receptors nor were sampling data analyzed in terms of nature and extent for individual ecological receptors (e.g., compared to ecologically based screening levels). However, results of routine monitoring and specific on-site studies were used to confirm the transport of contaminants from subsurface to surface soil to locations outside the SDA and into the food web. Data also were used to identify and substantiate the need for analyzing particular pathways of exposure. Contaminant samples that have been collected and analyzed for biotic media at WAG 7 are discussed in Section 4.

6.6.3.2 ***Contaminant Concentrations.*** Ideally, actual concentrations in abiotic and biotic media for the ecological COPCs would be used in the ecological risk assessment. However, most surface and subsurface soil data were collected before recontouring and alterations in the overburden thickness on the SDA (Becker et al. 1998). More recent soil sampling activities at the SDA have been limited. In addition, composite samples generally were collected for vegetation and tissue, and sampling locations were not specifically documented. Collocated samples were not collected for all media (both vegetation and soil); therefore, exposure factors and concentrations cannot be reconstructed from EM or RESL biotic data. Rather, the DOSTOMAN model was used to generate COPC concentrations across the SDA to allow evaluation of receptors in terms of a population-level exposure. The model incorporates transport from subsurface to the surface by plant root uptake and animal intrusion (Section **5.4).** Biotic sampling conducted by WAG 7, Environmental Monitoring, and RESL were used as weight-of-evidence in the assessment.

6.6.3.2.1 DOSTOMAN Biotic Model Simulations—DOSTOMAN model calculations (see Section 6.6.3.2.1) were used to estimate potential surface and subsurface soil concentrations for radionuclide and nonradionuclide COPCs identified in Table 6-14. Modeling was similar to that conducted for the IRA (Becker et al. 1998). However, more representative assumptions with regard to biotic intrusion were applied. For example, average rather than maximum burrowing and rooting depths were applied and best-estimate inventory quantities were used. A detailed discussion of the DOSTOMAN biotic model can be found in Section 5.5.

The following general assumptions were used for the DOSTOMAN biotic model:

- Waste is distributed homogeneously across the SDA
- The current disturbed habitat will return to its native habitat in 200 years
- Measures to control shrub establishment will be maintained throughout the simulated 100-year institutional control period.

Soil concentrations were estimated with the DOSTOMAN model for the 13 source zones and then averaged across the SDA. Both plant uptake and release through plant death were modeled. Burrowing animal intrusion and burrow collapse as well as leaching and radioactive decay also were incorporated in the model. Soil concentrations in the 0 to 15-cm (0 to 6-in.) compartment were used to represent surface concentrations for this analysis. The maximum concentrations calculated in the compartments between 0.15 and 2.m (0.50 and 7.4 ft) were used to represent subsurface concentration levels.

A current scenario (for the year 2010) was analyzed to provide an estimate of current risk to ecological receptors at the initiation of remediation. The current scenario reflects plant production over a period of 100 years during which time the current vegetation community is maintained. Community composition for future scenarios was modeled for four separate periods to replicate change in community structure over time (e.g., 100 to 130 years, 130 to 150 years, 150 to 200, and greater than 200 years).

The 100-year scenario (for the year 2111) was evaluated to provide an estimate of soil concentrations at the hypothetical release after the 100-year simulated institutional control period. Plant-age composition for current and future scenarios was assumed to remain constant over the modeled period. Biomass calculations were based on a total community production and fractional contributions of individual plant species (NRCS 1981). Successional trends from the current SDA vegetation community were assumed to result in a natural community similar to sagebrush-grass communities surrounding the RWMC and other parts of the region (Anderson 1991; Anderson and Inouye 1988; NRCS 1981).

Surface and subsurface soil concentrations were simulated for 12 radionuclide and six nonradionuclide COPCs using the DOSTOMAN model and compared to EBSLs. An EBSL is defined as the concentration in soil or other media above which chronic exposure by ecological receptors can be expected to produce adverse effects (Kester et al. 1998). For this comparison, the lowest EBSL across all receptor groups and individuals was used (DOE-ID 1999b). For radiological contaminants, the lower EBSL between internal and external exposure EBSLs was used as a measure of conservatism. Parameter values and methods used to develop the most current EBSLs have been documented in detail in the OU 10-04 work plan (DOE-ID 1999b). A COPC was eliminated from further analysis when the calculated subsurface soil concentration was less than the minimum EBSL. As previously noted, both current and 100-year scenarios were evaluated using best-estimate inventories and revised model assumptions.

6.6.3.2.2 *Radionuclide Concentrations—*Simulations were generated for the 12 radionuclide COPCs shown in Table 6-15. Subsurface concentrations exceeded EBSLs for Am-241 and Sr-90 for the current scenario, and Am-241, Pu-239, Pu-240, and Sr-90 for the 100-year scenario (Table 6-15). Surface concentrations did not exceed EBSLs for any radionuclide COPC for either the current or 100-year scenario (Table 6-15).

Though designed for conservatism, the DOSTOMAN model apparently underpredicts surface concentrations between two and three orders of magnitude for some contaminants (Becker et al. 1998). However, calculated surface concentrations were two to four orders of magnitude below the minimum EBSL for all contaminants examined. Maximum concentrations that could be generated for most contaminants may not be reflected in the concentrations presented for the current and 100-year scenarios. Consequently, DOSTOMAN-generated values for (a) surface and subsurface concentration maximums, (b) the year those maximums are attained, and (c) the year in which EBSLs are first exceeded are summarized in Table 6-16. Contaminants for which concentration peaks exceed EBSLs are shown in bold text. The contaminants for which maximum concentration peaks exceed the EBSL in years beyond the 100-year scenario include Am-241, Pu-238, Pu-239, Pu-240, Pu-242, Ra-226, Sr-90, U-234, and U-238. Simulated maximum concentrations for all other contaminants were attained before the current or 100-year scenarios.

Am-241, Pu-239/240, and Sr-90 are further evaluated in Section 6.6.5 using the current and 100-year subsurface soil concentrations to calculate receptor exposures.

6.6.3.2.3 Nonradionuclide Concentrations—Surface and subsurface soil concentrations were generated for six of the 44 nonradionuclide COPCs identified in Section 6.6.3. The six COPCs represent the contaminants for which DOSTOMAN simulations were performed in the IRA (Becker et al. 1998). Only surface and subsurface soil concentrations for nitrate were revised with updated DOSTOMAN modeling to support the human health assessment (Section 6.1). Concentrations for most nonradionuclides could be generated only for the current scenario using uncertain disposal quantities and no concentrations could be estimated for the 100-year scenario. Surface concentrations, but no subsurface estimates, could be derived without modeling. Consequently, the six contaminants that were assessed for human health are used here as indicators of potential risk to ecological receptors from exposures to nonradionuclide contaminants. For the remaining ecological COPCs, the IRA upper-bound inventory estimates and more conservative DOSTOMAN model (Becker et al. 1998), were used in the assessment. Results from the review of ecological contaminant screening (Hampton and Becker 2000) also were used to calculate receptor exposures (Section 6.6.5).

Surface concentrations for all nonradionuclide COPCs were below **EBSLs** in both scenarios (Table 6-17). Subsurface concentrations exceeded **EBSLs** for cadmium and lead in both the current and 100-year scenario and for nitrates in the current scenario (Table 6-17). Though subsurface mercury concentrations in both scenarios exceeded the **EBSL** for organic mercury, subsurface concentrations were below the **EBSL** for inorganic mercury. Therefore, this COPC was not evaluated further.

Contaminants for which maximum concentration peaks exceed the **EBSL** in years beyond the 100-year scenario include cadmium, lead, and nitrate (Table 6-16). Simulated maximum concentrations for all other contaminants were attained before the current or 100-year scenarios.

Carbon tetrachloride, methylene chloride, and tetrachloroethane were not evaluated in this assessment because they were not modeled for the human health assessment. Cadmium, lead, and nitrate are further evaluated in Section 6.6.5 using the current and 100-year subsurface soil concentrations to calculate receptor exposures.

6.6.4 Exposure Analysis

Only exposure routes for the subsurface pathway are addressed for this assessment. Concentrations of WAG 7 COPCs in subsurface soil were simulated by the DOSTOMAN model to evaluate risk to ecological receptors. The surface soil pathway was eliminated through screening (see Section 6.5.2, Tables 6-15 and 6-16) and no surface water features or pathways to groundwater for ecological receptors exist on the SDA. The model for ecological pathways and exposure for WAG 7 contaminated subsurface soil is presented in Figure 6-94.

Contaminants in subsurface soil can be transported to ecological receptors by plant uptake and ingestion by herbivorous and burrowing animals. Animals receiving direct exposure are potential sources of indirect exposure when preyed upon by carnivorous receptors. Though inhalation and direct contact (by burrowing animals) are important exposure routes, they are not evaluated in **INEEL** ecological risk assessments because data and models have not been developed for ecological receptors.

Subsurface soil is defined at depths of 0.15 to 3 m (0.5 to 10 ft) for the receptor exposure analysis. Contamination depths greater than 3 m (10 ft) below ground surface are considered inaccessible to ecological receptors because this depth is generally below the root zone of plants and the burrowing depth of ground-dwelling animals.

The exposure model for the subsurface soil pathway is presented as a component of the WAG 7 conceptual site model shown in Figure 6-95. This model reflects both direct and indirect (i.e., predation) receptor exposure pathways for WAG 7 ecological COPCs.

Table 6-15. Comparison of estimated surface and subsurface soil concentrations for radionuclide ecological contaminants of potential concern to ecologically based screening levels.

Radionuclide Contaminant	Revised Inventory Disposal Quantity (Ci)[a]	Best-Estimate Concentration[b] (pCi/g)	Minimum Ecologically Based Screening Level[c] (pCi/g)	Estimated Current Surface Concentration[d] (pCi/g)	Estimated Current Subsurface Concentration[e] (pCi/g)	Estimated 100-year Surface Concentration (pCi/g)	Estimated 100-year Subsurface Concentration (pCi/g)
Am-241	**1.83E+05**	3.98E+05	1.78E+01	9.81E-03	**3.75E+02**	4.91E-02	**7.30E+02**
Am-243	1.34E+02	2.92E+02	**1.85E+01**	2.16E-06	7.90E-02	8.14E-06	7.78E-02
Cm-244	**5.24E+04**	**1.14E+05**	**1.68E+01**	6.54E-05	1.24E+01	7.32E-06	4.77E-01
Cs-137	**6.17E+05**	**1.34E+06**	**4.95E+03**	3.50E-02	8.19E+01	1.09E-01	1.02E+02
Nb-94	**1.00E+03**	2.19E+03	**1.87E+03**	2.32E-05	6.68E-01	4.05E-04	**2.90E+00**
Pu-238	1.71E+04	**3.72E+04**	1.78E+01	1.02E-05	**1.02E+00**	2.20E-05	7.33E-01
Pu-239	**6.49E+04**	1.41E+05	1.89E+01	1.10E-04	1.16E+01	6.63E-04	**2.63E+01**
Pu-240	**1.71E+04**	3.72E+04	**1.89E+01**	8.41E-05	1.06E+01	6.40E-04	**2.77E+01**
Pu-242	**1.65E+01**	**3.58E+01**	**2.00E+01**	7.75E-09	1.58E-03	4.66E-08	3.31E-03
Sr-90	4.52E+05	**9.84E+05**	3.34E+03	**9.61E+00**	**4.25E+03**	**7.26E+00**	**1.24E+03**
U-234	**6.74E+0** 1b	1.47E+02	**2.05E+01**	4.02E-07	7.53E-02	8.63E-07	1.46E-01
U-238	1.17E+02	**2.55E+02**	**2.32E+01**	5.38E-05	**8.80E+00**	7.20E-05	1.23E+01

a. A discussion of revised inventory disposal quantities is contained in Section 3.3.

b. Best-estimate concentrations were developed from inventory data collected as part of the Historical Data Task and Recent and Projected Data Task projects (Becker et al. 1996).

c. The minimum ecologically based screening level (EBSL) across receptor groups was selected for both radionuclide and nonradionuclide contaminants (DOE-ID 1999b). The smallest EBSLs between internal or external exposures were selected for radionuclide contaminants (DOE-ID 1999b).

d. The surface concentration is the DOSTOMAN concentration modeled for the 0 to 15-cm (0 to 6-in.) compartment for the given scenario.

e. The subsurface concentration is the maximum DOSTOMAN concentration from the lower profile for the given scenario (excluding the surface compartment).

Note: Bolded text indicates contaminants for which the simulated concentration exceeds the EBSL. This contaminant of potential concern is evaluated further in Section 6.5.3.

Table 6-16. Comparison of estimated surface and subsurface soil concentrations for nonradionuclide ecological contaminants of potential concern to ecologically based screening levels.

Nonradionuclide Contaminant[a]	Minimum Ecologically Based Screening Levels[b] (mg/kg)	Upperbound Concentration' (mg/kg)	Estimated Current Surface Concentration[d] (mg/kg)	Estimated Current Subsurface Concentration[e] (mg/kg)	Estimated 100-year Surface Concentration (mg/kg)	Estimated 100-year Subsurface Concentration (mg/kg)
Beryllium	7.14E-01	4.79E+01	1.16E-07	3.21E-03	1.44E-06	8.62E-03
Cadmium	2.36E-03	5.01E+00	1.71E-05	**3.58E-02**	9.64E-05	**1.03E-01**
Hydrazine	1.42E-03	4.79E-03	7.15E-15	7.87E-08	6.97E-34	4.25E-28
Lead	9.94E-01	1.70E+03	1.26E-03	**3.44E+01**	2.01E-02	**1.08E+02**
Mercury (total)[f,g]	**6.21E-03[h], 4.18E+00[I]**	**4.27E+00**	7.55E-05	9.29E-02	5.92E-04	2.64E-01
Nitrate (total)'	**1.84E+01**	1.35E+03	1.43E-02	**3.71E+01**	1.75E-11	1.31E-08

a. WSTOMAN analyses for human health were run only for these COPCs. No additional nonradionuclide COPCs were modeled for the ecological risk assessment.
b. The minimum EBSL across receptor groups was selected for both radionuclide and nonradionuclide contaminants (DOE-ID 1999b). The smallest EBSLs between internal or external exposures were selected for radionuclide contaminants (DOE-ID 1999b).
c. Concentrations were modeled using upper bound disposal inventory estimates and conservative model assumptions as presented in Hampton and Becker (2000).
d. The surface concentration is the DOSTOMAN concentration modeled for the 0 to 15-cm (0 to 6-in.) compartment for the given scenario.
e. The subsurface concentration is the maximum DOSTOMAN concentration from the lower profile for the given scenario (excluding the surface compartment).
f. The known disposal quantity for this contaminant is suspected to be smaller than the actual amount disposed of (Becker et al. 1998).
g. Total includes mercury and mercury nitrate monohydrate.
h. The EBSL for organic mercury (presented for reference hut not used in the ecological risk assessment).
i. The EBSL for inorganic mercury.
j. Total includes aluminum nitrate, ammonia, copper nitrate, mercury nitrate monohydrate, nitric acid, potassium nitrate, sodium nitrate, and uranyl nitrate.

Note: Bolded text indicates contaminants for which the simulated concentration exceeds the ecologically based screening level (EBSL). This contaminant of potential concern is evaluated further in Section 6.5.3.

Table 6-17. Summary of the simulated soil concentrations for Waste Area Group 7 ecological contaminants of potential concern.

Contaminant	Minimum Ecologically Based Screening Level (pCi/g or mg/kg)	Year Ecologically Based Screening Level was Exceeded	Concentration[a] (pCi/g or mg/kg)	Soil Interval (cm)	Maximum Concentration[a] (pCi/g or mg/kg)	Year of Maximum Concentration	Soil Interval (cm)
Am-241	**1.78E+01**	1962	**2.54E+01**	190 to 225	1.23E+03	2470 to 2613	190 to 225
Am-243	1.85E+01	**NA**	**NA**	**NA**	7.94E-02	1978 to 1979	190 to 225
Cm-244	1.68E+01	1977	2.13E+01	190 to 225	3.102E+01	1978	190 to 225
Cs-137	4.95E+03	**NA**	**NA**	**NA**	1.19E+02	2064 to 2080	190 to 225
Nb-94	1.87E+03	**NA**	**NA**	**NA**	2.11E+01	**2992[e]**	190 to 225
Pu-238	1.78E+01	**NA**	**NA**	**NA**	**1.06E+00**	1977 to 1979	190 to 225
Pu-239	**1.89E+01**	2061	1.90E+01	190 to 225	**1.52E+02**	**3002[e]**	190 to 225
Pu-240	**1.89E+01**	2060	1.91E+01	190 to 225	1.60E+02	2992 to **3002[e]**	190 to 225
Pu-242	**2.00E+01**	**NA**	**NA**	**NA**	5.46E-02	**3002[e]**	190 to 225
Sr-90	3.34E+03	1986	3.36E+03	190 to 225	**4.25E+03**	2008 to 2010	190 to 225
U-234	**2.05E+01**	**NA**	**NA**	**NA**	1.43E+00	2478 to 2504	190 to 225
U-238	2.32E+01	**NA**	**NA**	**NA**	**1.44E+00**	2197 to 2237	190 to 225
Beryllium[b]	7.14E-01	**NA**	**NA**	**NA**	5.46E-02	**3002[e]**	225 to 270
Cadmium[b]	2.36E-03	1963	5.09E-03	180 to 270	4.14E-01	3002"	225 to 270
Hydrazine[b]	1.42E-03	1973	1.67E-03	225 to 270	2.70E-03	1983	225 to 270
Lead[b]	9.94E-01	1966	**1.22E+00**	180 to 270	7.06E+02	**3002[e]**	225 to 270
Mercury[b]	6.21E-03[c] **4.18E+00[d]**	NA	**NA**	**NA**	**1.47E+00**	**3002[d]**	225 to 270
Nitrate (total)	**1.84E+01**	1968	2.03E+01	190 to 225	3.97E+01	1971	190 to 225

a. Units are pCi/g for radionuclides and mg/kg for nonradionuclides.
b. These contaminants were screened using more conservative modeling assumptions (e.g. maximum instead of average values for rooting and burrowing depths) (Hampton and Becker 2000).
c. The ecologically based screening level (EBSL) for organic mercury (presented for reference but not used in the ecological risk assessment).
d. The EBSL for inorganic mercury.
e. Concentrations for the contaminant were increasing at the final **DOSTOMAN** calculation for the year 3002.

NA = The EBSL for this contaminant was not exceeded for the modeled period.

Note: Bolded text indicates contaminants for which the maximum simulated concentration exceeds the EBSL.

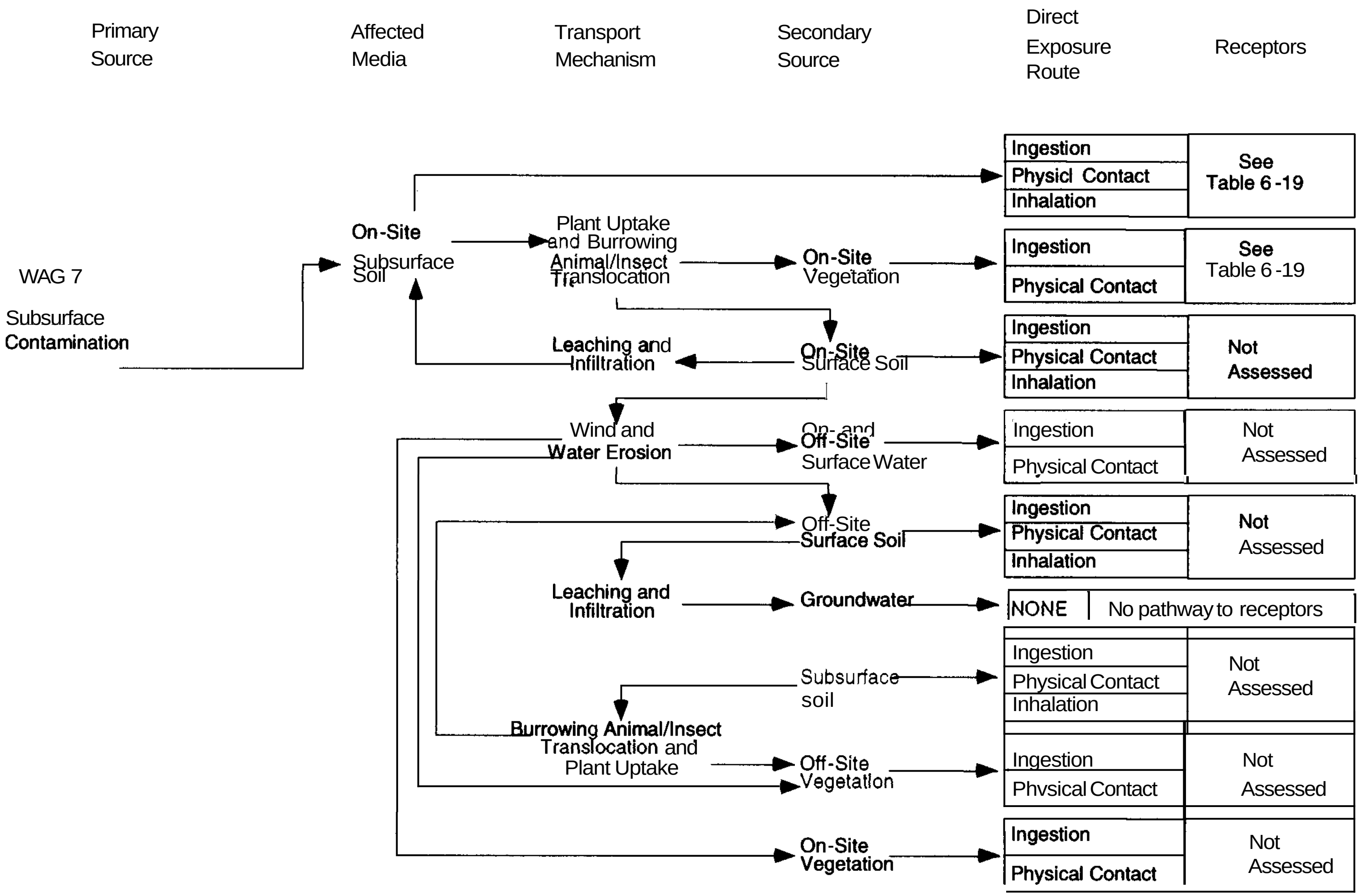

Figure 6-94. Model for ecological pathways and exposure for the Subsurface Disposal Area.

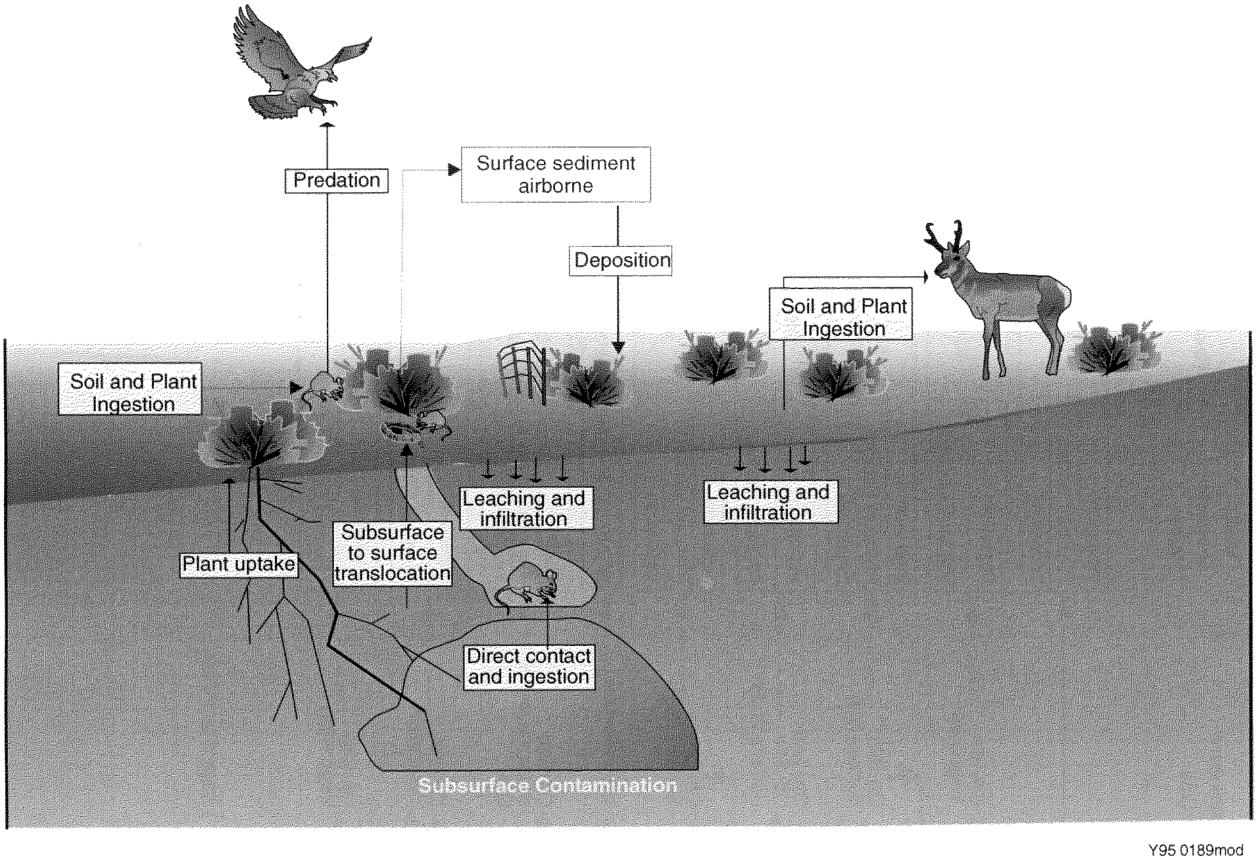

Figure 6-95. The Subsurface Disposal Area ecological conceptual site model.

6.6.4.1 Ecological Receptors. Modeled contaminant levels in surface soil at the SDA did not attain concentrations in levels expected to result in adverse effects to ecological receptors for any of the radionuclide and nonradionuclide COPCs evaluated (see Section 6.6.3, Tables 6-15, and 6-16). Consequently, potential receptors for which exposures have been assessed include only those anticipated to receive exposures from contact or ingestion of subsurface contamination (see Table 6-18). Representative receptors evaluated in the analysis were selected from three general biotic components of the WAC 7 ecological community:

- Burrowing animals
- Sensitive species
- Plants

Plants and burrowing animals, including insects, also are accounted for in the analysis as vectors of transport (*see* Section 5.4). However, because toxicity data are not available, insects were not specifically evaluated in the receptor exposure analysis.

Evaluated receptors comprise a combination of functional groups as described in Appendix E of VanHorn, Hampton, and Morris (1995) and individual T/E or sensitive species chosen to represent potential ingestion exposure routes contained in Table 6-19 in the subsurface model pathway (*see* Figure 6-94). Functional groups are the representative models for species in specific trophic levels and habitat locations.

Table 6-18. Receptors selected for analysis in the Waste Area Group 7 ecological risk assessment.

Species or Functional Group	Relationship to Exposure Analysis
Avian herbivores (AV122)	Represents herbivorous birds
Peregrine falcon	Sensitive species
Bald eagle	Sensitive species
Loggerhead shrike	Sensitive species: smallest avian carnivore
Burrowing owl	Sensitive species: representative avian carnivore
Mammalian herbivores (M122A)	Represents several common herbivorous burrowing species that are also prey for carnivores
Pygmy rabbit	Sensitive species: potential exposures by burrowing and herbivory
Townsends western big-eared bat	Sensitive species: representative of mammalian insectivores
Mammalian carnivores (M322)	Represents burrowing carnivores
Sagebrush lizard	Sensitive species: burrow inhabiting insectivore
Reptilian carnivores (R322)	Burrow inhabiting carnivores, prey is small mammals
Plants	Primary production, foodweb linkage

6.6.5 Ecological Risk Estimates

Methodology and models used to calculate receptor exposures for radionuclide and nonradionuclide COPCs are detailed in Appendix D3 of the OU 10-04 Work Plan for the Comprehensive RI/FS (DOE-ID 1999b). Models account for both internal and external radiation exposure and all routes of exposure through ingestion, including the uptake of contaminants by vegetation, concentration in prey, and direct ingestion of soil (see Table 6-19). Exposure parameters used to calculate dose to functional groups and individual species are presented in Table 6-20. Soil concentrations simulated by the DOSTOMAN model and used to calculate doses to the selected WAG 7 ecological receptors are discussed in Section 6.6.4. ***An*** HQ was then developed for individual receptor or contaminant combination by comparing the calculated dose to a contaminant-specific toxicity reference value (TRV) as shown in Equation (6-1). The TRVs used for calculating HQs for WAG 7 COPCs were taken from the OU 10-04 Work Plan or the Comprehensive RI/FS (DOE-ID 1999b).

Table 6-19. Summary of Waste Area Group 7 exposure routes and ecological receptors modeled for the subsurface soil pathway.

Exposure Medium	Exposure Route[a]	Modeled Receptors (Functional Groups)
Subsurface soil (direct)	Ingestion (dietary) Physical contact (external radionuclides)	Avian herbivores Mammalian herbivores Pygmy rabbit Avian carnivores Mammalian carnivores Reptilian insectivores Loggerhead shrike Bald eagle Peregrine falcon
Vegetation (direct)	Ingestion	Avian herbivores Mammalian herbivores Pygmy rabbit
Prey (indirect)	Ingestion	Avian carnivores Mammalian carnivores Reptilian insectivores Loggerhead shrike Bald eagle Peregrine falcon Burrowing owl Townsend's western big-eared bat

a. The inhalation pathway was not evaluated in this assessment.

Use of chemical concentration data modeled for human health risk assessment is assumed to be representative of the range of concentrations to which ecological receptors using the SDA are likely to be exposed. If the dose from the contaminant does not exceed its TRV (i.e., HQs are less than 1.0 for nonradiological contaminants and less than 0.1 for radiological contaminants [VanHorn, Hampton, and Morris 1995]), adverse effects to ecological receptors from exposure to that contaminant are not expected, and no further evaluation of that contaminant is required. Therefore, the HQ is an indicator of potential risk. The HQs were calculated using the following equation:

$$HQ = \frac{Dose}{TRV} \tag{6-1}$$

where

HQ = hazard quotient (unitless)

Dose = dose from all media (mg/kg/day or pCi/g/day)

TRV = toxicity reference value (mg/kg/day or pCi/g/day).

Table 6-20. Species exposure model parameters.

Functional Groups	FP[a]	FV[b]	FS[c]	ED[d]	IR[e] (kg/day)	Ingestion Equation[f]	BW[g] (kg)	HR[h] (ha)
Avian herbivores (AV122)	0.00E+00	9.07E-01	9.30E-02	1.00E+00	1.46E-03	All birds	3.50E-03	5.18E+00
Peregrine falcon	9.80E-01	0.00E+00	2.00E-02	2.50E-01	4.96E-02	All birds	7.82E-01	3.31E+01
Bald eagle	9.80E-01	0.00E+00	2.00E-02	2.50E-01	1.60E-01	All birds	4.74E+00	4.94E+02
Ferruginous hawk	9.80E-01	0.00E+00	2.00E-02	6.50E-01	6.19E-02	All birds	1.10E+00	5.60E+02
Loggerhead shrike	9.80E-01	0.00E+00	2.00E-02	6.50E-01	7.44E-03	All birds	4.25E-02	4.57E+00
Avian carnivores (AV322A)	9.70E-01	0.00E+00	3.00E-02	2.50E-01	1.73E-02	All birds	1.55E-01	1.00E+01
Burrowing owl	9.70E-01	0.00E+00	3.00E-02	2.50E-01	1.73E-02	All birds	1.55E-01	1.00E+01
Mammalian herbivores (M122)	0.00E+00	9.37E-01	6.30E-02	1.00E+00	3.30E-03	Mammalian herbivore	4.65E+01	2.30E-01
Mammalian herbivores (M122A)	0.00E+00	9.23E-01	7.70E-02	1.00E+00	4.27E-03	Mammalian herbivore	1.57E-02	3.00E-01
Pygmy rabbit	0.00E+00	9.80E-01	2.00E-02	1.00E+00	4.53E-02	Mammalian herbivore	4.04E-01	2.80E-01
Townsend's western big-eared bat	9.90E-01	0.00E+00	1.00E-02	1.00E+00	2.37E-03	Rodents	1.10E-02	2.39E+00
Mammalian carnivores (M322)	9.23E-01	0.00E+00	7.70E-02	1.00E+00	1.66E-02	All mammals	1.78E-01	1.30E+01
Sagebrush lizard	9.76E-01	0.00E+00	2.40E-02	1.00E+00	5.60E-05	Reptilian insectivore	6.61E-03	1.17E-01
Reptilian carnivores (R322)	9.52E-01	0.00+00	4.80E-02	1.00E+00	6.80E-03	Literature value	1.50E-02	3.00E+00
Plants	NA	NA	1.00	1.00	NA	NA	NA	NA

a. FP = fraction of diet represented by prey ingested (unitless). Herbivores = 0% prey, total FV = FV FS; carnivores = 0% vegetation, total FP - FS): and omnivores =(1.00 - FS)/2 for FP and FV.
b. FV = fraction of diet represented by vegetation ingested (unitless).
c. FS = fraction of diet represented by soil ingested (unitless). Soil ingestion for pronghorn antelope and jackrabbits from Beyer, **Connor,** and Gerould **(1994)** and Arthur and Gates **(1988).**
d. ED = exposure duration (fraction of year spent in the affected area) (unitless). Conventions: Residents of species = 0.05 to 1.00 (birds and migratory and transient mammals) and 1.00 for small mammals; breeding = 0.05 to 0.65 for birds and migratory and transient mammals; summer visitors = 0.05 – 0.25; winter visitors = 0.05 to 0.25.
e. IR = ingestion rate (derived using allometric equations based on body weight [Nagy **1987])** (i.e., kg/day).
f. Ingestion equation used for calculating ingestion rates (Nagy **1987).**
g. BW = receptor-specific body weight (kg). Mammalian body weights were taken primarily from Burt and Grossenheider **(1976)** and the U.S. Environmental Protection Agency ***Wildlife Exposure Factors Handbook*** **(1993).** Avian body weights were taken from Dunning **(1993).**
h. Home ranges were taken from Hoover and Wills **(1987).**

Hazard quotients were derived for all contaminants, functional groups, and T/E and C2 species identified in Section 6.5.4. If information was not available to derive a TRV, then an HQ could not be developed for that particular contaminant and functional group or sensitive species combination.

An HQ greater than or equal to 1.0 for nonradiological contaminants or greater than or equal to 0.1 for radiological contaminants indicates that exposure to a given contaminant (at the concentrations and for the duration and frequencies of exposure estimated in the exposure assessment) may cause adverse health effects in exposed populations. However, the level of concern associated with exposure may not increase linearly as HQ values exceed the target value. This means that the HQ values cannot be used to represent a probability or a percentage because an HQ of 10 does not necessarily indicate that adverse effects are 10 times more likely to occur than an HQ of 1.0. It is only possible to infer that the greater the HQ, the greater the concern about potential adverse effects to ecological receptors.

6.6.5.1 Uncertainty Association with Hazard Quotients. An HQ is used as an indicator of risk for this assessment. The HQ is a ratio of the calculated dose for a receptor from a COPC to the TRV. These ratios provide a quantitative index of risk to defined functional groups or individual receptors under assumed exposure conditions. The ratio, or HQ method, is commonly used in both human health assessments and ecological risk assessments. It has been used in INEEL WAG ecological risk assessments to eliminate contaminants and sites that do not pose a risk to the ecosystem from further assessment.

The significance of exceeding a target HQ value depends on the perceived value (i.e., ecological, social, or political) of the receptor, the nature of the endpoint measured, and the degree of uncertainty associated with the process as a whole. Therefore, the decision to take no further action, order corrective action, or perform additional assessment should be approached on a site-, chemical-, and species-specific basis. Because the unit of concern in an ecological risk assessment is usually the population as opposed to the individual, with the exception of T/E species (EPA 1992b), exceeding conservative screening criteria does not necessarily mean that significant adverse effects are likely.

An HQ less than 1.0 for nonradionuclides and less than 0.1 for radionuclides implies a low likelihood of the adverse effects from that contaminant (Van Horn, Hampton, and Morris 1995). Nonradiological and radiological contaminants are treated separately because exposure mechanisms differ between these two classes of contaminants. Effects from the nonradioactive metals are expected to cause systemic toxicity while effects to reproductive processes are typically associated with exposure to ionizing radiation. A separate approach also could be used in which the target HQ is set to $1/n$, where n is the number of nonradiological or radiological contaminants of concern. This approach would be too conservative for nonradiological contaminants because it assumes cumulative exposure to all nonradionuclides and that all contaminants within a given group behave synergistically in a given receptor. Given that all receptors within a functional group may not be simultaneously exposed to all contaminants, and that a synergistic effect may not be seen, this approach may be more stringent than necessary to protect all ecological receptors from nonradiological effects. Therefore, the target HQ is 1 for all nonradiological contaminants. This method may underestimate risk because the method does not account for cumulative exposure to multiple contaminants by a given receptor.

At this level in the ecological risk assessment approach at the INEEL, both exposure and toxicity assumptions are generally conservative and represent the upper bound of potential risks to ecological receptors. The HQ approach does not consider variability and uncertainty in either exposure or toxicity estimates and, therefore, does not represent a statistical probability of occurrence of adverse ecological effects. The HQs essentially provide a yes or no determination of risk and, thus, are well suited for screening-level assessments (EPA 1988). A limitation of the quotient method is that it does not predict the degree of risk or the magnitude of effects associated with specified levels of contamination (EPA 1988).

6.6.5.2 Results

6.6.5.2.1 Current ***Scenario***—Hazard quotients generated from internal and external exposures associated with radionuclide COPC concentrations simulated in subsurface soil for the current scenario are presented in Table 6-2I. Internal HQs for all avian species and functional groups exceeded the target value of 0.1 for both Am-241 and Sr-90. Hazard quotients for Am-241 ranged from 0.4 for the bald eagle to 21 for avian herbivores, mammals, and reptiles. Hazard quotient values for Sr-90 ranged from 0.5 for the bald eagle to 25 for avian herbivores, mammals, and reptiles. External exposure HQs for Am-241 were well below the target of 0.1 for all receptors for both the current and 100-year scenarios. However, external HQs for Sr-90 exceeded 0.1 for avian herbivores, mammals, and reptiles. External HQs for Sr-90 ranged from 0.007 for the bald eagle to 0.4 for avian herbivores and all mammal groups and species.

Table 6-21. Hazard quotients for ecological internal and external exposure from subsurface soil for the current scenario.

	Am-241		Sr-90	
Receptor	**Internal**	**External**	**Internal**	**External**[a]
Avian herbivores (AV122)	**21.1**	<0.1	**25.4**	**0.4**
Peregrine falcon	**5.7**	<0.1	**6.4**	**0.1**
Bald eagle	**0.4**	<0.1	**0.5**	<0.1
Loggerhead shrike	**13.7**	<0.1	**17.0**	**.25**
Burrowing owl	**5.3**	<0.1	**6.4**	<0.1
Mammalian herbivores (M122A)	**21.1**	<0.1	**25.4**	**0.4**
Pygmy rabbit	**21.1**	<0.1	**25.4**	**0.4**
Townsend's big-eared bat	**21.1**	<0.1	**25.4**	**0.4**
Mammalian carnivores (M322)	**21.1**	<0.1	**25.4**	**0.4**
Sagebrush lizard	**21.1**	<0.1	**25.4**	**0.4**
Reptilian carnivores (R322)	**21.1**	<0.1	**25.4**	**0.4**
Plants	**2.3**	<0.1	**2.7**	<0.1

Note: Bolded text indicates a hazard quotient that exceeds 0.1 for **radionuclides.**
a. Includes external exposure for **daughter products.**

Hazard quotients generated from exposures associated with nonradionuclide concentrations simulated in subsurface soil for the current scenario are presented in Table 6-22. Hazard quotients for cadmium exceeded the target value of 1 for all mammalian receptors, with HQs ranging from 2 for the pygmy rabbit to 9 for Townsend's western big-eared bat. Lead concentrations resulted in HQs that exceeded the target of I for three of the five avian receptors, ranging from 2 for the burrowing owl to 6 for the loggerhead shrike. In addition, the lead HQ for Townsend's western big-eared bat was 2. Nitrate HQs exceeded 1 for avian herbivores, loggerhead shrike, and all mammalian receptors, ranging from 1 for both the pygmy rabbit and mammalian carnivores to 10 for avian herbivores. Risks from all nonradionuclide COPCs could not be evaluated for reptiles because no toxicity data existed with which to develop a TRV.

6.6.5.2.2 700-Year ***Scenario***—Hazard quotients generated from internal and external exposures associated with radionuclide COPC concentrations for the 100-year scenario are presented in Table 6-23. Internal HQs for all species and functional groups exceeded the target value of 0.1 for Am-241 ranging from 0.7 for the bald eagle to 41 for avian herbivores and all mammalian and reptilian receptors. Internal HQs for Pu-239 and Pu-240 also exceeded 0.1 for all receptors except the bald eagle.

Hazard quotients for Pu-239 ranged from 0.4 for the peregrine falcon and burrowing owl to greater than 1 for avian herbivores and all mammalian and reptilian receptors. The HQs for Pu-240 ranged from 0.4 for the peregrine falcon and burrowing owl to greater than 1.5 for avian herbivores and all mammalian and reptilian receptors. Quotient values for Sr-90 ranged from 0.5 for the bald eagle to 25 for avian herbivores and all mammalian and reptilian receptors. External exposure HQs for Am-241, Pu-239, and Pu-240 were well below the target of 0.1 for all receptors for the 100-year scenario.

Table 6-22. Hazard quotients for selected nonradionuclide ecological contaminants of potential concern for the current scenario.

Receptor	Cadmium	Lead	Nitrate
Avian herbivores (AV122)	**<1**	**3**	**10**
Peregrine falcon	<1	<1	<1
Bald eagle	<1	<1	<1
Loggerhead shrike	<1	**6**	**3**
Burrowing owl	<1	**2**	<1
Mammalian herbivores (M122)	**7**	**<1**	**4**
Pygmy rabbit	**2**	<1	**1**
Townsend's western big-eared bat	9	**2**	**3**
Mammalian carnivore (M322)	**7**	**<1**	**1**
Sagebrush lizard	NA	NA	NA
Reptilian carnivores (R322)	NA	NA	NA
Plants	<1	<1	NA

Note: Bolded text indicates a hazard quotient that exceeds 1 for nonradionuclides.
NA = not applicable. An appropriate toxicity reference value cannot be developed for this ecological contaminant of potential concern.

Table 6-23. Hazard quotients for ecological internal and external exposure from subsurface soil for the 100-year scenario.

	Am-241		Pu-239		Pu-240	
Receptor	Internal	External	Internal	External	Internal	External
Avian herbivores (AV122)	**41.0**	<0.1	**1.4**	<0.1	**1.5**	<0.1
Peregrine falcon	**10.3**	<0.1	**0.4**	<0.1	**0.4**	<0.1
Bald eagle	**0.7**	<0.1	<0.1	<0.1	<0.1	<0.1
Loggerhead shrike	**26.7**	<0.1	**0.9**	<0.1	0.9	<0.1
Burrowing owl	**10.3**	<0.1	**0.4**	<0.1	**0.4**	<0.1
Mammalian herbivores (M122A)	**41.0**	<0.1	**1.4**	<0.1	**1.5**	<0.1
Pygmy rabbit	**41.0**	<0.1	**1.4**	<0.1	**1.5**	<0.1
Townsend's western big-eared bat	**41.0**	<0.1	**1.4**	<0.1	**1.5**	<0.1
Mammalian carnivores (M322)	**41.0**	<0.1	**1.4**	<0.1	**1.5**	<0.1
Sagebrush lizard	**41.0**	<0.1	**1.4**	**<**0.1	**1.5**	<0.1
Reptilian carnivores (R322)	**41.0**	<0.1	**1.4**	**<**0.1	**1.5**	<0.1
Plants	**4.2**	<0.1	<0.1	<0.1	<0.1	<0.1

Note: Bolded text indicates a hazard quotient that exceeds 0.1 for radionuclides.

Hazard quotients generated from exposures associated with nonradionuclide COPC concentrations for the 100-year scenario are presented in Table 6-24. Hazard quotients for cadmium exceeded the target value of 1 for all mammalian receptors, with HQs ranging from 8 for the pygmy rabbit to 30 for Townsend's western big-eared bat. Lead concentrations resulted in HQs that exceeded the target of 1 for four of the five avian receptors, ranging from 3 for the peregrine falcon to 20 for the loggerhead shrike. Only the HQ for the bald eagle was below the target value. Hazard quotients for lead also exceeded the target for Townsend's western big-eared bat, mammalian carnivores, and plants. All HQs for nitrate were less than 0.1 for the 100-year scenario.

Table 6-24. Hazard quotients for selected nonradionuclide ecological contaminants of potential concern for the 100-year scenario.

Receptor	Cadmium	Lead	Nitrate
Avian herbivores (AV122)	<1	**9**	<1
Peregrine falcon	<1	**3**	<1
Bald eagle	<1	<1	<1
Loggerhead shrike	<1	**20**	<1
Burrowing owl	<1	**6**	<1
Mammalian herbivores (M122)	**20**	<1	<1
Pygmy rabbit	**8**	<1	<1
Townsends western big-eared bat	**3**	**8**	<1
Mammalian carnivores (M322)	**2**	**3**	<1
Sagebrush lizard	**NA**	**NA**	**NA**
Reptilian carnivores (R322)	**NA**	**NA**	**NA**
Plants	<1	**2**	**NA**

Note: Bolded text indicates a hazard quotient that exceeds 1 **for nonradionuclides.**
NA = not applicable. An appropriate toxicity reference value cannot be developed for this contaminant of potential concern.

6.6.6 Ecological Risk Evaluation

All radionuclide COPCs identified in the WAG 7 preliminary screening were evaluated in this assessment. Six of 44 nonradionuclide COPCs were evaluated as indicators of potential risk for this group of contaminants (see Section 6.6.2). The 38 nonradionuclide COPCs that were not specifically analyzed in this assessment are presented in Table 6-25.

The assessment endpoint for the WAG 7 ecological risk assessment was the indication of risk to ecological receptors, determined by HQ values that exceeded target values for either the current or 100-year scenario. The WAG 7 contaminants shown to pose risk to ecological receptors (i.e., HQs greater than 10 times the target value [DOE-ID 1999a]) include Am-241, Sr-90, Pu-240, Pu-239, cadmium, lead, and nitrate. The risk to ecological receptors posed by exposure to these contaminants also was shown to be limited primarily to the subsurface soil profile for the scenarios evaluated. Plant uptake and burrowing by animals are not shown to increase current surface soil concentration to adverse levels during the next 100 years.

Table 6-25. Contaminants that were not specifically evaluated as part of the Waste Area Group 7 ecological risk assessment.

1,1,2-trichloro-1,2,2-trifluoroethane	**Organophosphates (tributylphosphate)**
3-methylcholanthrene	**Organic acids (ascorbic acid)**
Alcohols	Potassium chloride
Aluminum nitrate	Potassium hydroxide
Asbestos	Potassium nitrate
Carbon tetrachloride	Potassium phosphate
Chloroform	Potassium sulfate
Dibutylethylcarbutol	Sodium chloride
Ether	Sodium **cyanide**
Ethyl alcohol	**Sodium nitrate**
Hydrofluoric acid	Sodium phosphate
Lithium hydride	Sodium-potassium
Lithium oxide	Sulfuric acid
Manganese	Tetrachloroethylene
Magnesium oxide	Trimethylpropane-triester
Methylene chloride	**Toluene**
Nitrobenzene	**Versenes (EDTA)**
Nitrocellulose	Xylene
Nitric acid	**Copper (total)**

Note: Bolded text indicates contaminants for which inadequate data exist to allow further analysis (see Hampton and Becker 2000).

Subsurface soil concentrations for Am-241, Sr-90, and nitrate pose current risk to receptors. Risks to ecological receptors posed by Am-241, Pu-239, Pu-240, cadmium, and lead increase up to and beyond the simulated 100-year institutional control period (see Table 6-16). However, the maximum concentrations modeled for Sr-90 and nitrate peak before the year 2010 (see Table 6-16), and by the end of the simulated institutional control period at year 2110, these contaminants fall below the levels expected to pose risk to ecological receptors. Current concentrations for Pu-239/240 do not show risk, but increase over the simulated 100-year institutional control period to unacceptable levels.

Soil concentrations were generated by the DOSTOMAN model from 1952 to the year 3002. Maximum subsurface concentrations for Am-241 were attained in the year 2470. Example HQs calculated for the maximum concentration are approximately three times higher than those for the current scenario (14 for the loggerhead shrike in the year 2010 and 45 in the year 2470), but are nearly the same as HQs at the end of the simulated 100-year institutional control period (41 for the loggerhead shrike in the year 2110). Concentrations for Pu-239 and Pu-240 were shown to increase beyond the year 3002. Hazard quotients in the 100-year scenario for these contaminants are substantially smaller than those for Am-241 (i.e., less than 2), but will increase over three-fold with the maximum modeled concentration (i.e., less than 2 for avian herbivores in the year 2110 and 7 in the year 3002). Maximum surface concentrations were not shown to increase to adverse levels for any COPC over the modeled period.

Though modeled soil concentrations were not quantitatively compared to sampling data for this assessment, a cursory examination of concentrations in biotic tissue in and around the SDA shows that concentrations of Am-241 and Sr-90 are much higher in plant and animal tissue than are concentrations of Pu-239 and Pu-240 (see Section 4.9). This generally supports the predicted trend of higher HQs for Am-241 than for Pu-239 and Pu-240.

Concentrations of cadmium and lead continue to increase beyond the modeled period. Example HQs for cadmium, calculated for the maximum modeled concentration, are more than four times higher than those for the 100-year scenario (i.e., 20 for mammalian herbivores and carnivores in the year 2110 and 90 in the year 3002). Hazard quotients for lead at maximum modeled concentrations are 10 times those calculated for the 100-year scenario (i.e., 20 for the loggerhead shrike in the year 2110 and 200 in the year 3002). Human health sampling data were not compared to modeled concentrations for this assessment, and no biotic data have been collected for these contaminants on the SDA.

Current risk from subsurface contamination is posed by all WAG 7 ecological contaminants of concern and, without remedial action, risk will continue beyond the 100-year simulated institutional control period. Risks for the nonradionuclide COPCs presented on Table 6-25 were not evaluated. In addition, several COPCs eliminated in the screening because risk was not demonstrated for the current and 100-year scenarios (e.g., mercury, beryllium, and Nb-94) were also shown by the model to be increasing with time (see Table 6-16). This suggests that in the absence of remediation to control current intrusion by biotic receptors, risk over the long term may increase above levels identified in this assessment.

6.7 References

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